IN THE UNITED STATES DISTRICT COURT
FOR THE DISTRICT OF DELAWARE

PARKER-HANNIFIN CORPORATION, and PARKER INTANGIBLES, LLC, Plaintiffs, v. ZIPPERTUBING (JAPAN), LTD., Defendant.	:	C.A. No. 06-751-MPT
PARKER-HANNIFIN CORPORATION, and PARKER INTANGIBLES, LLC, Plaintiffs, v. SEIREN CO., LTD., Defendant.	:	C.A. No. 07-104-MPT

DECLARATION OF STEVEN A. NASH IN SUPPORT OF PLAINTIFFS' OPENING CLAIM CONSTRUCTION BRIEF
[EXHIBIT D FILED UNDER SEAL]

I, Steven A. Nash, do hereby declare:

1. I am an attorney admitted to practice *pro hac vice* before this Court. I make this Declaration in support of Plaintiffs Parker-Hannifin Corporation and Parker Intangibles, LLC's Opening Claim Construction Brief.

2. Attached hereto as Exhibit A is a true and correct copy of U.S. Pat. No. 6,521,348 ("the '348 patent").

3. Attached hereto as Exhibit B is a true and correct copy of U.S. Pat. No. 6,716,536 ("the '536 patent").

4. Attached hereto as Exhibit C is a true and correct copy of U.S. Pat. No. 6,777,095 ("the '095 patent").

5. Attached hereto as Exhibit D is a true and correct copy of Underwriters Laboratories Standard No. 94 **[FILED UNDER SEAL].**

6. Attached hereto as Exhibit E is a true and correct copy of a letter sent by counsel for Zippertubing to counsel for Parker on May 16, 2008.

7. Attached hereto as Exhibit F is a products data sheet from Rogers Corporation for BISCO® HT-840 foam.

8. Attached hereto as Exhibit G is a true and correct copy of selected pages from Webster's New Twentieth Century Dictionary of the English Language Unabridged, Second Ed. (1979).

9. Attached hereto as Exhibit H is a true and correct copy of a Preliminary Amendment submitted to the USPTO on March 10, 2004 during the prosecution of the application that subsequently issued as the '095 patent.

I hereby declare under penalty of perjury that all of the statements made by me herein are true.

Dated: July 1, 2008

Steven A. Nash

EXHIBIT
A

US006521348B2

(12) **United States Patent**
Bunyan et al.

(10) **Patent No.: US 6,521,348 B2**
(45) **Date of Patent: *Feb. 18, 2003**

(54) **FLAME RETARDANT EMI SHIELDING GASKET**

(75) Inventors: **Michael H. Bunyan**, Chelmsford, MA (US); **William I. Flanders**, Merimack, NH (US)

(73) Assignee: **Parker-Hannifin Corp.**, Cleveland, OH (US)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

This patent is subject to a terminal disclaimer.

(21) Appl. No.: **10/142,803**

(22) Filed: **May 9, 2002**

(65) **Prior Publication Data**

US 2002/0125026 A1 Sep. 12, 2002

Related U.S. Application Data

(63) Continuation of application No. 09/883,785, filed on Jun. 18, 2001, now Pat. No. 6,387,523, which is a continuation of application No. 09/250,338, filed on Feb. 16, 1999, now Pat. No. 6,428,393.

(60) Provisional application No. 60/076,370, filed on Feb. 27, 1998.

(51) **Int. Cl.**[7] **B32B 5/14**; B32B 5/18; H05K 9/00

(52) **U.S. Cl.** **428/457**; 361/818

(58) **Field of Search** 427/77; 361/818; 428/457

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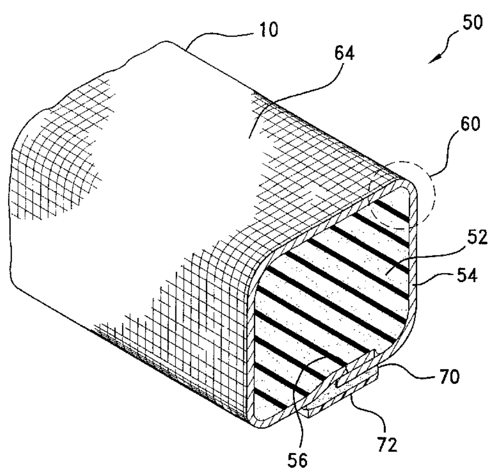
(List continued on next page.)

Primary Examiner—Erma Cameron
(74) *Attorney, Agent, or Firm*—John A. Molnar, Jr.

(57) **ABSTRACT**

A flame retardant, electromagnetic interference (EMI) shielding gasket construction. The construction includes a resilient core member formed of a foamed elastomeric material, an electrically-conductive fabric member surrounding the outer surface of the core member, and a flame retardant layer coating at least a portion of the interior surface of the fabric member. The flame retardant layer is effective to afford the gasket construction with a flame class rating of V-0 under Underwriter's Laboratories (UL) Standard No. 94.

18 Claims, 3 Drawing Sheets



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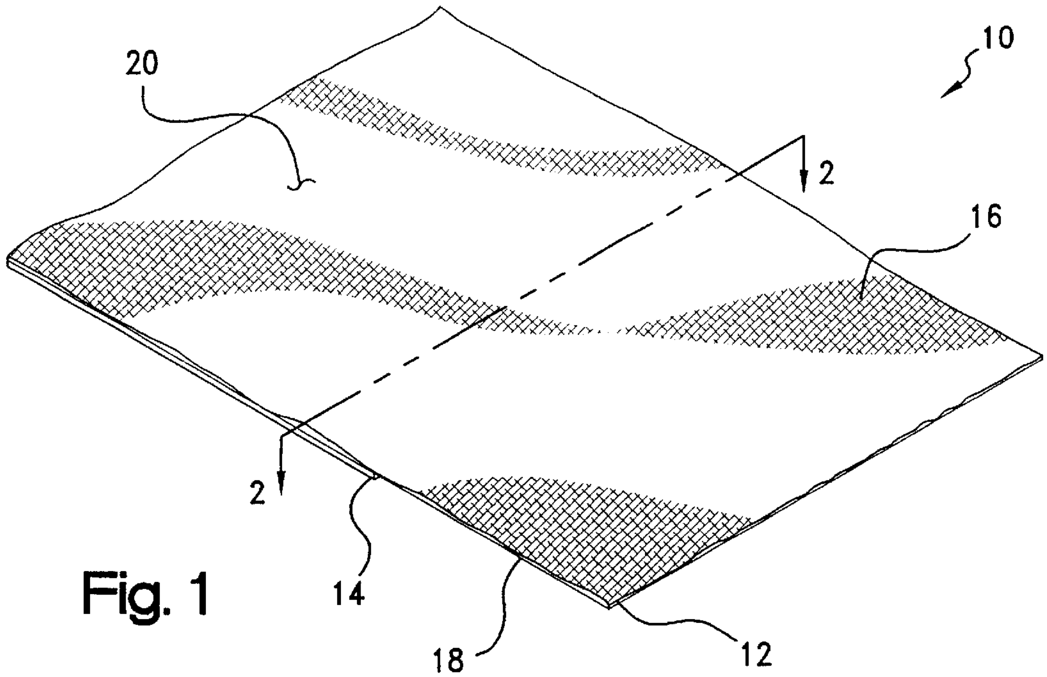

Fig. 1

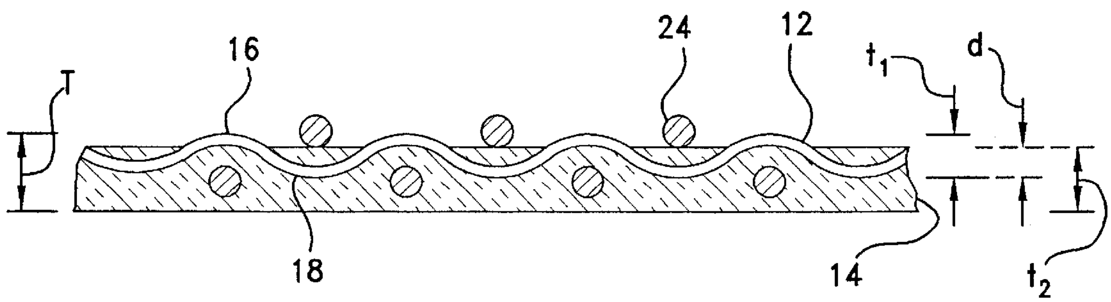

Fig. 2

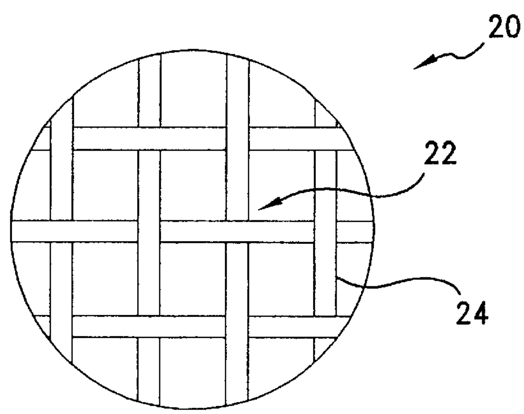

Fig. 3

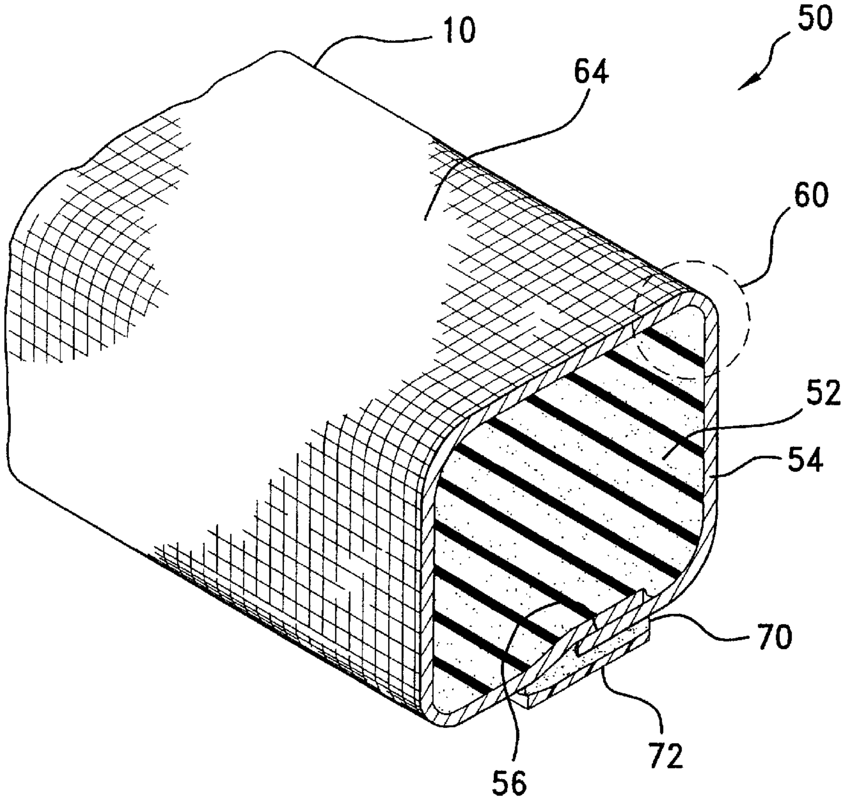

Fig. 4

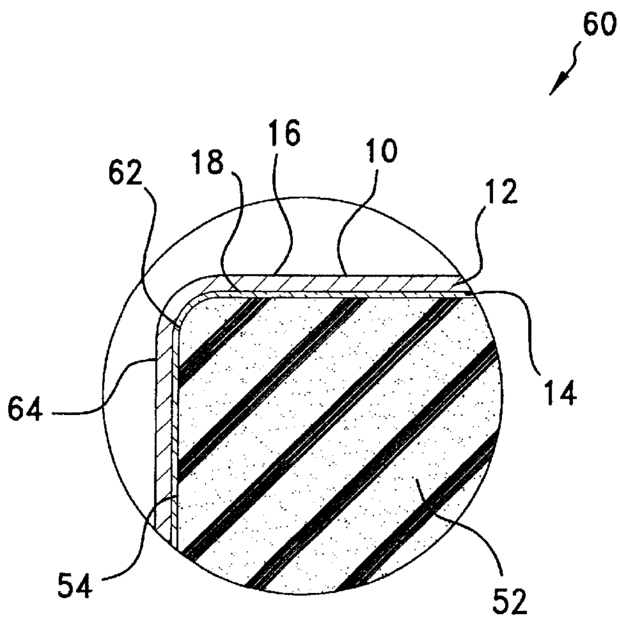

Fig. 5

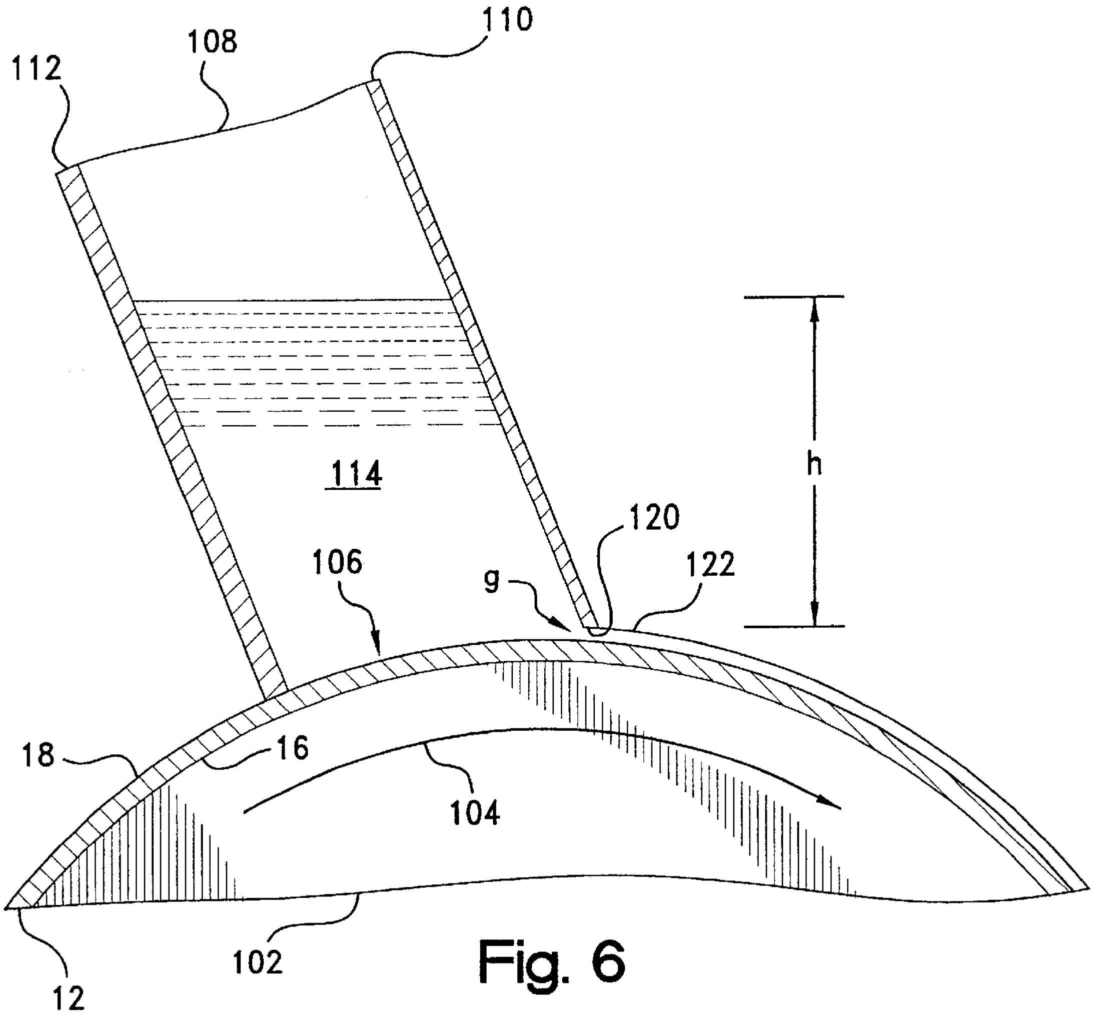

Fig. 6

FLAME RETARDANT EMI SHIELDING GASKET

CROSS-REFERENCE TO RELATED APPLICATION

This application is a continuation of U.S. application Ser. No. 09/883,785, filed Jun. 18, 2001, which application is to issue as U.S. Pat. No. 6,387,523; which is a continuation of U.S. application Ser. No. 09/250,338, filed Feb. 16, 1999, now U.S. Pat. No. 6,428,393 and claiming priority to U.S. provisional application Serial No. 60/076,370, filed Feb. 27, 1998, the disclosure of each of which is expressly incorporated herein by reference.

BACKGROUND OF THE INVENTION

The present invention relates broadly to electrically-conductive, flame retardant materials for use in electromagnetic interference (EMI) shielding, and to a method of manufacturing the same, and more particularly to an electrically-conductive fabric having a layer of a flame retardant coating applied to one surface thereof for use as a sheathing within an EMI shielding gasket.

The operation of electronic devices including televisions, radios, computers, medical instruments, business machines, communications equipment, and the like is attended by the generation of electromagnetic radiation within the electronic circuitry of the equipment. Such radiation often develops as a field or as transients within the radio frequency band of the electromagnetic spectrum, i.e., between about 10 KHz and 10 GHz, and is termed "electromagnetic interference" or "EMI" as being known to interfere with the operation of other proximate electronic devices.

To attenuate EMI effects, shielding having the capability of absorbing and/or reflecting EMI energy may be employed both to confine the EMI energy within a source device, and to insulate that device or other "target" devices from other source devices. Such shielding is provided as a barrier which is inserted between the source and the other devices, and typically is configured as an electrically conductive and grounded housing which encloses the device. As the circuitry of the device generally must remain accessible for servicing or the like, most housings are provided with openable or removable accesses such as doors, hatches, panels, or covers. Between even the flattest of these accesses and its corresponding mating or faying surface, however, there may be present gaps which reduce the efficiency of the shielding by presenting openings through which radiant energy may leak or otherwise pass into or out of the device. Moreover, such gaps represent discontinuities in the surface and ground conductivity of the housing or other shielding, and may even generate a secondary source of EMI radiation by functioning as a form of slot antenna. In this regard, bulk or surface currents induced within the housing develop voltage gradients across any interface gaps in the shielding, which gaps thereby function as antennas which radiate EMI noise. In general, the amplitude of the noise is proportional to the gap length, with the width of the gap having a less appreciable effect.

For filling gaps within mating surfaces of housings and other EMI shielding structures, gaskets and other seals have been proposed both for maintaining electrical continuity across the structure, and for excluding from the interior of the device such contaminates as moisture and dust. Such seals are bonded or mechanically attached to, or press-fit into, one of the mating surfaces, and function to close any interface gaps to establish a continuous conductive path

thereacross by conforming under an applied pressure to irregularities between the surfaces. Accordingly, seals intended for EMI shielding applications are specified to be of a construction which not only provides electrical surface conductivity even while under compression, but which also has a resiliency allowing the seals to conform to the size of the gap. The seals additionally must be wear resistant, economical to manufacture, and capability of withstanding repeated compression and relaxation cycles. For further information on specifications for EMI shielding gaskets, reference may be had to Severinsen, J., "Gaskets That Block EMI," Machine Design, Vol. 47, No. 19, pp. 74–77 (Aug. 7, 1975).

Requirements for typical EMI shielding applications often dictate a low impedance, low profile gasket which is deflectable under normal closure force loads. Other requirements include low cost and a design which provides an EMI shielding effectiveness for both the proper operation of the device and compliance, in the United States, with commercial Federal Communication Commission (FCC) EMC regulations.

A particularly economical gasket construction, which also requires very low closure forces, i.e. less than about 1 lb/inch (0.175 N/mm), is marketed by the Chomerics Division of Parker-Hannifin Corp., Woburn, Mass. under the tradename "Soft-Shield® 5000 Series." Such construction consists of an electrically-conductive jacket or sheathing which is "cigarette" wrapped lengthwise over a polyurethane or other foam core. As is described further in U.S. Pat. No. 4,871,477, polyurethane foams generally are produced by the reaction of polyisocyanate and a hydroxyl-functional polyol in the presence of a blowing agent. The blowing agent effects the expansion of the polymer structure into a multiplicity of open or closed cells.

The jacket is provided as a highly conductive, i.e., about 1 Ω-sq., nickel-plated-silver, woven rip-stop nylon which is self-terminating when cut. Advantageously, the jacket may be bonded to the core in a continuous molding process wherein the foam is blown or expanded within the jacket as the jacket is wrapped around the expanding foam and the foam and jacket are passed through a die and into a traveling molding. Similar gasket constructions are shown in commonly-assigned U.S. Pat. No. 5,028,739 and in U.S. Pat. Nos. 4,857,668; 5,054,635; 5,105,056; and 5,202,536.

Many electronic devices, including PC's and communication equipment, must not only comply with certain FCC requirements, but also must meet be approved under certain Underwriter's Laboratories (UL) standards for flame retardancy. In this regard, if each of the individual components within an electronic device is UL approved, then the device itself does not require separate approval. Ensuring UL approval for each component therefore reduces the cost of compliance for the manufacturer, and ultimately may result in cheaper goods for the consumer. For EMI shielding gaskets, however, such gaskets must be made flame retardant, i.e., achieving a rating of V-0 under UL Std. No. 94, "Tests for Flammability of Plastic Materials for Parts in Devices and Appliances" (1991), without compromising the electrical conductivity necessary for meeting EMI shielding requirements.

In this regard, and particularly with respect to EMI shielding gaskets of the above-described fabric over foam variety, it has long been recognized that foamed polymeric materials are flammable and, in certain circumstances, may present a fire hazard. Owing to their cellular structure, high organic content, and surface area, most foam materials are

subject to relatively rapid decomposition upon exposure to fire or high temperatures.

One approach for imparting flame retardancy to fabric over foam gaskets has been to employ the sheathing as a flame resistant protective layer for the foam. Indeed, V-0 rating compliance purportedly has been achieved by sheathing the foam within an electrically-conductive Ni/Cu-plated fabric to which a thermoplastic sheet is hot nipped or otherwise fusion bonding to the underside thereof. Such fabrics, which may be further described in one or more of U.S. Pat. Nos. 4,489,126; 4,531,994; 4,608,104; and/or 4,621,013, have been marketed by Monsanto Co., St. Louis, under the tradename "Flectron® Ni/Cu Polyester Taffeta V0."

Other fabric over foam gaskets, as is detailed in U.S. Pat. No. 4,857,668, incorporate a supplemental layer or coating applied to the interior surface of the sheath. Such coating may be a flame-retardant urethane formulation which also promotes the adhesion of the sheath to the foam. The coating additionally may function to reduce bleeding of the foam through the fabric which otherwise could compromise the electrical conductivity of the sheath.

In view of the foregoing, it will be appreciated that further improvements in the design of flame retardant, fabric-over foam EMI shielding gaskets, as well as sheathing materials therefore, would be well-received by the electronics industry. Especially desired would be a flame retardant gasket construction which achieves a UL94 rating of V-0.

BROAD STATEMENT OF THE INVENTION

The present invention is directed to an electrically-conductive, flame retardant material for use in fabric-over-foam EMI shielding gaskets, and to a method of manufacturing the same. In having a layer of a flame retardant coating applied to one side of an electrically-conductive, generally porous fabric, the material of the invention affords UL94 V-0 protection when used as a jacketing in a fabric-over-foam gasket construction. Advantageously, as the flame retardant layer may be wet coated on the fabric without appreciable bleed through, a relatively thin, i.e., 2–4 mil (0.05–0.10 mm), coating layer may be provided on one fabric side without compromising the electrical surface conductivity of the other side. Such a thin coating layer, while being sufficient to provide UL94 V-0 protection, nonetheless maintains the drapability the fabric and thereby facilitates the construction UL94 V-0 compliant gaskets having complex profiles or narrow cross-sections down to about 1 mm.

In a preferred embodiment, the electrically-conductive, flame retardant EMI shielding material of the invention includes a nickel or silver-plated, woven nylon, polyester, or like fabric on one side of which is wet coated a layer of a flame retardant, acrylic latex emulsion or other fluent resin composition. In accordance with the precepts of the method of the invention, the viscosity and hydrodynamic pressure of the emulsion are controlled such that the coating does not penetrate or otherwise "bleed through" the uncoated side of the fabric. The surface conductivity of the opposite side of the fabric therefore is not compromised in EMI shielding applications.

The material of the invention may be employed as a jacket in fabric-over-foam EMI shielding gasket constructions, and is particularly adapted for use in the continuous molding process for such gaskets. As used within such process, the fabric may be wrapped around the foam as a jacket with coated side thereof being disposed as an interior surface

adjacent the foam, and the uncoated side being disposed as an electrically-conductive exterior surface. Advantageously, the coating on the interior surface of the jacket blocks the pores of the fabric to retain the foam therein without penetrate or bleed through to the exterior surface. In being formed of a acrylic material, the coated interior surface of the jacket may function, moreover, depending upon the composition of the foam, as a compatibilizing or "tie" interlayer which promotes the bonding of the foam to the fabric.

The present invention, accordingly, comprises material and method possessing the construction, combination of elements, and arrangement of parts and steps which are exemplified in the detailed disclosure to follow. Advantages of the present invention include a flame retardant yet drapable EMI shielding fabric. Additional advantages include an economical, flame retardant EMI shielding fabric construction wherein a relatively thin layer of a flame retardant coating may be wet coated onto one side of an electrically-conductive, woven or other generally porous EMI shielding fabric without compromising the conductivity of the other side of the fabric. These and other advantages will be readily apparent to those skilled in the art based upon the disclosure contained herein.

BRIEF DESCRIPTION OF THE DRAWINGS

For a fuller understanding of the nature and objects of the invention, reference should be had to the following detailed description taken in connection with the accompanying drawings wherein:

FIG. **1** is a perspective view of one embodiment of an EMI shielding material according to the present invention which material includes a generally planar fabric member on one side of which is coated a layer of a flame retardant composition, the view being shown with portions being broken away to better reveal the structure of the material;

FIG. **2** is an enlarged cross-sectional view of the EMI shielding material of FIG. **1** taken through plane represented by line **2**—**2** of FIG. **1**;

FIG. **3** is a top view of the material of FIG. **1** which is magnified to reveal the structure of the fabric member thereof;

FIG. **4** is a perspective cross-sectional view of a length of a representative EMI shielding gasket construction according to the present invention including a jacket which is formed of the EMI shielding material of FIG. **1**;

FIG. **5** is an end view of the gasket of FIG. **4** which is magnified to reveal the structure thereof; and

FIG. **6** is a schematic, partially cross-sectional view of an illustrative gravity-fed, knife over roll coater as adapted for use in the manufacture of the EMI shielding material of FIG. **1**.

The drawings will be described further in connection with the following Detailed Description of the Invention.

DETAILED DESCRIPTION OF THE INVENTION

Certain terminology may be employed in the description to follow for convenience rather than for any limiting purpose. For example, the terms "upper" and "lower" designate directions in the drawings to which reference is made, with the terms "inner" or "interior" and "outer" or "exterior" referring, respectively, to directions toward and away from the center of the referenced element, and the terms "radial" and "axial" referring, respectively, to directions perpendicu-

lar and parallel to the longitudinal central axis of the referenced element. Terminology of similar import other than the words specifically mentioned above likewise is to be considered as being used for purposes of convenience rather than in any limiting sense.

For the illustrative purposes of the discourse to follow, the electromagnetic interference (EMI) shielding material herein involved is described in connection with its use as a flame retardant, electrically-conductive jacket for a foam core, EMI shielding gasket as may be adapted to be received within an interface, such as between a door, panel, hatch, cover, or other parting line of an electromagnetic interference (EMI) shielding structure. The EMI shielding structure may be the conductive housing of a computer, communications equipment, or other electronic device or equipment which generates EMI radiation or is susceptible to the effects thereof. The gasket may be bonded or fastened to, or press-fit into one of a pair of mating surfaces which define the interface within the housing, and functions between the mating surfaces to seal any interface gaps or other irregularities. That is, while under an applied pressure, the gasket resiliently conforms to any such irregularities both to establish a continuous conductive path across the interface, and to environmentally seal the interior of the housing against the ingress of dust, moisture, or other contaminates. It will be appreciated, however, that aspects of the present invention may find utility in other EMI shielding applications. Use within those such other applications therefore should be considered to be expressly within the scope of the present invention.

Referring then to the figures, wherein corresponding reference characters are used to designate corresponding elements throughout the several views, a flame retardant EMI shielding material according to the present invention is shown generally at 10 in FIG. **1** as generally adapted for use as a jacket within for a foam core gasket construction. For purposes of illustration, material sheet **10** is shown to be of indefinite dimensions which may be cut to size for the particular application envisioned. In basic construction, material **10** includes an upper, generally planar and porous fabric member, **12**, and a lower, flame retardant coating member, **14**.

Fabric member has at least an electrically-conductive first side, **16**, and a conductive or non-conductive second side, **18**, defining a thickness dimension, referenced at "t_1" in the cross-sectional view of FIG. **2**, which may vary from about 2–4 mils (0.05–0.10 mm). By "electrically-conductive," it is meant that the fabric may be rendered conductive, i.e., to a surface resistivity of about 0.1 Ω/sq. or less, by reason of its being constructed of electrically-conductive wire, monofilaments, yams or other fibers or, alternatively, by reason of a treatment such as a plating or sputtering being applied to non-conductive fibers to provide an electrically-conductive layer thereon. Preferred electrically-conductive fibers include Monel nickel-copper alloy, silver-plated copper, nickel-clad copper, Ferrex® tin-plated copper-clad steel, aluminum, tin-clad copper, phosphor bronze, carbon, graphite, and conductive polymers. Preferred non-conductive fibers include cotton, wool, silk, cellulose, polyester, polyamide, nylon, and polyimide monofilaments or yarns which are rendered electrically conductive with a metal plating of copper, nickel, silver, nickel-plated-silver, aluminum, tin, or an alloy thereof. As is known, the metal plating may applied to individual fiber strands or to the surfaces of the fabric after weaving, knitting, or other fabrication.

While fabrics such as wire meshes, knits, and non-woven cloths and webs may find application, a preferred fabric

construction for member **12** is a plain weave nylon or polyester cloth which is made electrically conductive with between about 20–40% by weight based on the total fabric weight, i.e., 0.01–0.10 g/in^2, of a silver, nickel-silver, or silver-nickel over copper plating. As may be seen in the magnified view of FIG. **1** referenced at **20** in FIG. **3**, such cloth is permeable in having a plain, generally square weave pattern with pores or openings, one of which is referenced at **22**, being defined between the fibers which are represented schematically at **24**. Fibers **24** may be yams, monofilaments or, preferably, bundles of from about 10–20 filaments or threads, each having a diameter of between about 10–50 gm. For example, with fibers **24** each being a bundle of such threads with a thread count of between about 1000–3000 per inch and a weave count of between about 1000–1500 per inch, 1000–2000 openings per inch will be defined with a mean average pore size of between about 0.5–2 mils (12.5–50 μm).

Although a plain, square weave pattern such as a taffeta, tabby, or ripstop is considered preferred, other weaves such as satins, twills, and the like also should be considered within the scope of the invention herein involved. A particularly preferred cloth for fabric member **12** is a 4 mil (0.10 mm) thick, 1.8 oz/yd^2 weight, silver-plated, woven nylon which is marketed commercially under the designation "31EN RIPSTOP" by Swift Textile Metalizing Corp., Bloomfield, Conn. However, depending upon the needs of the specific shielding application, a fabric constructed of a combination or blend of conductive and nonconductive fibers alternatively may be employed. Examples of fabrics woven, braided, or warp knitted from electrically-conductive fibers, or from blends of conductive and non-conductive fibers, are described in Gladfelter, U.S. Pat. No. 4,684,762, and in Buonanno, U.S. Pat. No. 4,857,668.

Returning to FIGS. **1** and **2**, coating member **14** preferably is formed from a curable layer of a fluent, flame retardant resin or other composition which is wet coated onto the second side **18** of fabric member **12**. As is detailed hereinafter, the viscosity and hydrodynamic pressure of the resin composition are controlled in accordance with the precepts of the present invention to delimit the penetration of the resin layer to a depth, referenced at "d" in FIG. **2**, which is less than the thickness dimension t_1 of the fabric member **12**. In this regard, when the layer is cured to form the flame retardant surface coating member **14** on the second side **18** of fabric member **12**, the first side **16** thereof remains electrically-conductive. In a preferred construction, the layer is coated to a wet thickness of about 10 mils (0.25 mm), and then cured to a dried coating or film thickness, referenced at t_2 in FIG. **2**, of between about 2–4 mils (0.05–0.10 mm) at a depth d of about 1–2 mils (0.025–0.05 mm). Ultimately, a total material thickness, referenced at "T," of between about 6–7 mils (0.15–0.20 mm) and a dried weight pickup of between about 100–150 g/yd^2 are observed. By "cured" it is meant that the resin is polymerized, cross-linked, further cross-linked or polymerized, vulcanized, hardened, dried, volatilized, or otherwise chemically or physically changed from a liquid or other fluent form into a solid polymeric or elastomeric phase.

The flame retardant composition preferably is formulated as an aqueous emulsion of an acrylic latex emulsion which is adjusted to a total solids of about 60% and a Brookfield viscosity (#5 spindle, 4 speed) of between about 40,000–60,000 cps, at a density of about 10 lbs per gallon (1.8 g/cm^3). Flame retardancy may be imparted by loading the emulsion with between about 30–50% by weight of one or more conventional flame retardant additives such as aluminum

hydrate, antimony trioxide, phosphate esters, or halogenated compounds such as polybrominated diphenyl oxides. A preferred formulation is a mixture of about 25% by weight, based on the total weight of the emulsion, of decambromodiphenyl oxide and about 15% by weight of one or more antimony compounds. In operation, should the acrylic carrier phase be ignited, the decomposition of the halogenated and metal oxide compounds function to chemically deprive the flame of sufficient oxygen to support combustion. The decomposition of the acrylic phase additionally may lead to the development of a protective, i.e., thermally-insulative or refractory, outer char layer.

A preferred flame retardant, acrylic latex emulsion is marketed commercially by Heveatex Corp., Fall River, Mass., under the designation "4129FR." The viscosity of the emulsion may be adjusted to between about 40,000–60,000 cps using an aqueous acryloid gel or other acrylic thickener. In this regard, the increased viscosity of the emulsion contributes to delimiting the penetration of the coating layer into the fabric member. However, as this relatively high viscosity may lead to undesirable porosity in the dried film, the emulsion additionally may be modified to reduce air entrapment and bubble formation in the coating layer with up to about 1% by weight of one or more commercial surfactants such as "Bubble Breaker" by Witco Chemical Corp. (Chicago, Ill.) and "Foam Master Antifoam" by Diamond Shamrock, Inc. (San Antonio, Tex.).

As aforementioned, EMI shielding material **10** of the present invention is particularly adapted for use as a flame retardant, electrically-conductive jacket which is provided over a foam core in an EMI shielding gasket construction such as gasket **50** of FIG. **4**. In a representative embodiment, gasket **50** includes an elongate, resilient foam core member, **52**, which may be of an indefinite length. Core member **52** has an outer circumferential surface, **54**, defining the cross-sectional profile of gasket **50** which, for illustrative purposes, is of a generally polygonal, i.e., square or rectangular geometry. Other plane profiles, such as circular, semicircular, or elliptical, or complex profiles may be substituted, however, depending upon the geometry of the interface to be sealed. Core member **12** may be of any radial or diametric extent, but for most applications will have a diametric extent or width of from about 0.25 inch (0.64 cm) to 1 inch (2.54 cm).

For affording gap-filling capabilities, it is preferred that core member **52** is provided to be complaint over a wide range of temperatures, and to exhibit good compression-relaxation hysteresis even after repeated cyclings or long compressive dwells. Core member **52** therefore may be formed of a foamed elastomeric thermoplastic such as a polyethylene, polypropylene, polypropylene-EPDM blend, butadiene, styrene-butadiene, nitrile, chlorosulfonate, or a foamed neoprene, urethane, or silicone. Preferred materials of construction include open or closed cell urethanes or blends such as a polyolefin resin/monoolefin copolymer blend, or a neoprene, silicone, or nitrile sponge rubber.

Core member **52** may be provided as an extruded or molded foam profile over which shielding material **10** is wrapped as a sheathed, with the edges of sheathed being overlapped as at **56**. In a preferred construction, shielding material **10** is bonded to the core member **52** in a continuous molding process wherein the foam is blown or expanded within the shielding material. As may be seen best with reference to the magnified view of FIG. **4** referenced at **60** in FIG. **5**, in such construction coating member **14** is disposed adjacent core member **52** as an interior surface, **62**, of shielding member **10**, with the uncoated side **16** of fabric

member **12** being oppositely disposed as an electrically-conductive exterior surface, **64**, of the gasket **50**. It will be appreciated that the coated interior surface **62** blocks the pores **22** (FIG. **3**) of the fabric member **12** of the fabric to retain the blown foam therein without penetrate or bleed through to the exterior gasket surface **64**. Depending upon the respective compositions of the foam and coating, the interior surface **62** may function, moreover, as a compatibilizing or "tie" interlayer which promotes the bonding of the foam to the fabric. Gasket construction **50** advantageously provides a structure that may be used in very low closure force, i.e. less than about 1 lb/inch (0.175 N/mm), applications.

Referring again to FIG. **4**, an adhesive layer, **70**, may be applied along the lengthwise extent of gasket **50** to the underside of exterior surface **64** for the attachment of the gasket to a substrate. Such layer **70** preferably is formulated to be of a pressure sensitive adhesive (PSA) variety. As is described in U.S. Pat. No. 4,988,550, suitable PSA's for EMI shielding applications include formulations based on silicones, neoprene, styrene butadiene copolymers, acrylics, acrylates, polyvinyl ethers, polyvinyl acetate copolymers, polyisobutylenes, and mixtures, blends, and copolymers thereof. Acrylic-based formulations, however, generally are considered to be preferred for the EMI applications of the type herein involved. Although PSA's are preferred for adhesive layer **70**, other adhesives such as epoxies and urethanes may be substituted and, accordingly, are to be considered within the scope of the present invention. Heat-fusible adhesives such a hot-melts and thermoplastic films additionally may find applicability.

Inasmuch as the bulk conductivity of gasket **50** is determined substantially through its surface contact with the substrate, an electrically-conductive PSA may be preferred to ensure optimal EMI shielding performance. Such adhesives conventionally are formulated as containing about 1–25% by weight of a conductive filler to yield a volume resistivity of from about 0.01–0.001 Ω-cm. The filler may be incorporated in the form of particles, fibers, flakes, microspheres, or microballoons, and may range in size of from about 1–100 microns. Typically filler materials include inherently conductive material such as metals, carbon, and graphite, or nonconductive materials such as plastic or glass having a plating of a conductive material such as a noble metal or the like. In this regard, the means by which the adhesive is rendered electrically conductive is not considered to be a critical aspect of the present invention, such that any means achieving the desired conductivity and adhesion are to be considered suitable.

For protecting the outer portion of adhesive layer **70** which is exposed on the exterior surface of the gasket, a release sheets, shown at **72**, may be provided as removably attached to the exposed adhesive. As is common in the adhesive art, release sheet **72** may be provided as strip of a waxed, siliconized, or other coated paper or plastic sheet or the like having a relatively low surface energy so as to be removable without appreciable lifting of the adhesive from the exterior surface **64**.

In the production of commercial quantities of the EMI shielding material **10** of the present invention, the viscosity adjusted and otherwise modified acrylic latex emulsion or other resin composition may be coated and cured on one side the fabric member **12** by a direct wet process such as knife over roll or slot die. With whatever process is employed, the hydrodynamic pressure of the resin composition is controlled in accordance with the precepts of the present invention to delimit the penetration of the resin layer to a depth

which is less than the thickness dimension of the fabric member. For example, and with reference to FIG. **6** wherein the head of a representative gravity-fed knife over roll coater is shown somewhat schematically at **100**, porous, i.e., permeable, fabric member **12** is conveyed from a feed roll or the like (not shown) over a nip roller, **102**, which rotates in the direction referenced by arrow **104**. With the first side **16** of fabric member **12** supported on roller **102**, the fabric second side **18** is passed beneath the opening, referenced at **106**, of a coating trough, **108**. Trough **108** is defined by a front plate, **110**, a back plate, **112**, and a pair of side plates (not shown).

The emulsion or other fluent resin composition, referenced at **114**, is pumped or otherwise transported into trough **108** which is filled to a fluid level, referenced at h. For a given fluid density, this level h is controlled such that the hydrodynamic pressure at the fabric-liquid interface is maintained within preset limits. For example, with a fluid density of about 10 pounds per gallon (1.8 g/cm^3), and a fabric having a porosity of about 1000–2000 openings per inch with a mean average pore size of between about 0.5–2 mils (12.5–50 μm), the fluid level H is controlled at about 4 inches (10 cm) to yield a hydrodynamic pressure of about 0.05 psi (0.35 kPa) at the fabric-liquid interface. For other coating processes, the hydrodynamic fluid pressure may be controlled, for example, by a pumping pressure or the like.

In the illustrative knife-over-roll coating process, the lower edge, **120**, of front plate **110** defines a knife surface which is shimmed or otherwise spaced-apart a predetermined distance from the second side **18** of fabric member **12**. Such spacing provides a clearance or gap, referenced at "g," of typically about 10 mils (0.25 mm), but which is adjustable to regulate the thickness of the liquid coating layer, **122**, being applied to the fabric member. From roller **104**, the coated fabric member **12** may be conveyed via a take-up roller arrangement (not shown) through a in-line oven or the like to dry or flash the water or other diluent in the liquid coating layer **122**, or to otherwise cure the liquid coating layer **122** in developing an adherent, tack-free, film or other layer of coating member **14** (FIG. **1**) on the single side **18** of fabric member **12**.

The Example to follow, wherein all percentages and proportions are by weight unless otherwise expressly indicated, is illustrative of the practicing of the invention herein involved, but should not be construed in any limiting sense.

EXAMPLE

Representative EMI shielding materials according to the present invention were constructed for characterization. In this regard, a master batch of a flame retardant coating composition was compounded using an acrylic latex emulsion (Heveatex "4129FR"). The viscosity of the emulsion was adjusted to a Brookfield viscosity (#4 spindle, 40 speed) of about 60,000 cps with about 5 wt % of an acryloid thickener (Acrysol™ GS, Monsanto Co., St. Louis, Mo.). The modified emulsion had a total solids content of about 60% by weight, a density of about 10 pounds per gallon (1.8 g/cm^3), and a pH of between about 7.5 and 9.5.

The emulsion was applied using a knife over roll coater (JETZONE Model 7319, Wolverine Corp., Merrimac, Mass.) to one side of a silver-plated nylon fabric (Swift "31EN RIPSTOP") having a thickness of about 4 mils (0.1 mm). With the fluid level in the coating trough of the coater maintained at about 4 inch (10 cm), the emulsion was delivered to the surface of the cloth at a hydrodynamic pressure of about 0.05 psi (0.35 kPa). The coating knife was shimmed to a 10 mil (0.25 mm) gap above the fabric to yield a wet coating draw down thickness of about 10 mils. Following an oven curing at 100–125° C. for 5 minutes, a dried coating or film thickness of about 2.5 mils (0.635 mm) was obtained with a weight pickup of about 130–145 g/yd^2 and a total material thickness of between about 6–7 mils (0.15–0.18 mm). An inspection of the coated fabric cloth revealed a coating penetration depth of about 1–2 mils (0.02–0.05 mm) providing acceptable mechanical retention and/or adhesion of the coating onto the fabric surface. The opposite side of the fabric, however, was observed to be substantially coating free, and to retain a surface resistivity of about 0.1 Ω/sq for unaffected EMI shielding effectiveness.

Fabric samples similarly coated in the manner described were subjected to an in-house vertical flame test. No burning was observed at dried film thickness of 2, 3, or 4 mils (0.05, 0.08, 0.10 mm). Accordingly, a reasonable operating window of film thickness was suggested for production runs.

Samples also were provided, as jacketed over a polyurethane foam core in an EMI shielding gasket construction, for flame testing by Underwriters Laboratories, Inc., Melville, N.Y. A flame class rating of V-0 under UL94 was assigned at a minimum thickness of 1.0 mm. The gasket construction therefore was found to be compliant with the applicable UL requirements, and was approved to bear the "UL" certification mark.

The foregoing results confirm that the EMI shielding material of the present invention affords UL94 V-0 protection when used as a jacketing in a fabric-over-foam gasket construction. Unexpectedly, it was found that a relatively porous or permeable fabric may be wet coated on one side with a relatively thin, i.e., 2–4 mil (0.05–0.10 mm), coating layer of a flame retardant composition without compromising the electrical surface conductivity of the other side. Such a thin coating layer, while being sufficient to provide UL94 V-0 protection in a conventional fabric-over-foam gasket construction, nonetheless maintains the drapability the fabric and thereby facilitates the fabrication of UL94 V-0 compliant gaskets having complex profiles or narrow cross-sections down to about 1 mm.

As it is anticipated that certain changes may be made in the present invention without departing from the precepts herein involved, it is intended that all matter contained in the foregoing description shall be interpreted as illustrative and not in a limiting sense. All references cited herein are expressly incorporated by reference.

What is claimed is:

1. A flame retardant, electromagnetic interference (EMI) shielding gasket comprising:

a resilient core member which is not V-0 rated under Underwriter's Laboratories (UL) Standard No. 94 extending lengthwise along a central longitudinal axis and having an outer surface extending circumferentially about said longitudinal axis, said core member being formed of a foamed elastomeric material;

an electrically-conductive fabric member surrounding the outer surface of said core member, said fabric member having an interior surface disposed facing the outer surface of said core member and an oppositely-facing, exterior surface, at least the exterior surface being electrically-conductive and the exterior surface defining with the interior surface a thickness dimension of the fabric member therebetween; and

a flame retardant layer coating at least a portion of the interior surface of said fabric member, said flame

retardant layer being effective to afford said gasket a flame class rating of V-0 under Underwriter's Laboratories (UL) Standard No. 94 and penetrating into said fabric member to a depth which is less than the thickness dimension of said fabric member such that the exterior surface of said fabric member remains electrically-conductive.

2. The gasket of claim **1** wherein said flame retardant layer has a thickness of between about 2–4 mils (0.05–0.10 mm).

3. The gasket of claim **1** wherein said flame retardant layer is formed as a cured film of a flame retardant acrylic latex emulsion.

4. The gasket of claim **1** wherein said fabric member is a metal-plated cloth.

5. The gasket of claim **4** wherein said cloth comprises fibers selected from the group consisting of cotton, wool, silk, cellulose, polyester, polyamide, nylon, and combinations thereof, and said metal is selected from the group consisting of copper, nickel, silver, nickel-plated-silver, aluminum, tin, and combinations thereof.

6. The gasket of claim **1** wherein said foamed elastomeric material is selected from the group consisting of polyethylenes, polypropylenes, polypropylene-EPDM blends, butadienes, styrene-butadienes, nitriles, chlorosulfonates, neoprenes, urethanes, silicones, and polyolefin resin/monoolefin copolymer blends, and combinations thereof.

7. The gasket of claim **1** wherein said fabric member has a thickness of between about 2–4 mils (0.05–0.10 mm).

8. A flame retardant, electromagnetic interference (EMI) shielding gasket comprising:

a resilient core member extending lengthwise along a central longitudinal axis and having an outer surface extending circumferentially about said longitudinal axis, said core member being formed of a foamed elastomeric material;

an electrically-conductive fabric member surrounding the outer surface of said core member, said fabric member having an interior surface disposed facing the outer surface of said core member and an oppositely-facing, exterior surface, at least the exterior surface being electrically-conductive and the exterior surface defining with the interior surface a thickness dimension of the fabric member therebetween; and

a flame retardant layer coating at least a portion of the interior surface of said fabric member, said flame retardant layer comprising between about 30–50% by weight of one or more flame retardant additives and penetrating into said fabric member to a depth which is less than the thickness dimension of said fabric member such that the exterior surface of said fabric member remains electrically-conductive.

9. The gasket of claim **8** wherein said flame retardant layer has a thickness of between about 2–4 mils (0.05–0.10 mm).

10. The gasket of claim **8** wherein said flame retardant layer is formed as a cured film of a flame retardant acrylic latex emulsion.

11. The gasket of claim **8** wherein said fabric member is a metal-plated cloth.

12. The gasket of claim **11** wherein said cloth comprises fibers selected from the group consisting of cotton, wool, silk, cellulose, polyester, polyamide, nylon, and combinations thereof, and said metal is selected from the group consisting of copper, nickel, silver, nickel-plated-silver, aluminum, tin, and combinations thereof.

13. The gasket of claim **8** wherein said foamed elastomeric material is selected from the group consisting of polyethylenes, polypropylenes, polypropylene-EPDM blends, butadienes, styrene-butadienes, nitriles, chlorosulfonates, neoprenes, urethanes, silicones, and polyolefin resin/monoolefin copolymer blends, and combinations thereof.

14. The gasket of claim **8** wherein said fabric member has a thickness of between about 2–4 mils (0.05–0.10 mm).

15. The gasket of claim **8** wherein said flame retardant layer is effective to afford the gasket a flame class rating of V-0 under Underwriter's Laboratories (UL) Standard No. 94.

16. The gasket of claim **15** wherein said core member is not V-0 rated under Underwriter's Laboratories (UL) Standard No. 94.

17. The gasket of claim **8** wherein said core member is not V-0 rated under Underwriter's Laboratories (UL) Standard No. 94.

18. The gasket of claim **8** wherein said one or more flame retardant additives are selected from the group consisting of aluminum hydrate, antimony trioxide, phosphate esters, and halogenated compounds.

* * * * *

EXHIBIT
B

US006716536B2

(12) **United States Patent**
Bunyan et al.

(10) **Patent No.: US 6,716,536 B2**
(45) **Date of Patent: *Apr. 6, 2004**

(54) **FLAME RETARDANT EMI SHIELDING GASKET**

(75) Inventors: **Michael H. Bunyan**, Chelmsford, MA (US); **William I. Flanders**, Merimack, NH (US)

(73) Assignee: **Parker-Hannifin Corporation**, Cleveland, OH (US)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

This patent is subject to a terminal disclaimer.

(21) Appl. No.: **10/318,609**

(22) Filed: **Dec. 11, 2002**

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Related U.S. Application Data

(63) Continuation of application No. 10/142,803, filed on May 9, 2002, now Pat. No. 6,521,348, which is a continuation of application No. 09/883,785, filed on Jun. 18, 2001, now Pat. No. 6,387,523, which is a continuation of application No. 09/250,338, filed on Feb. 16, 1999, now Pat. No. 6,248,393.

(60) Provisional application No. 60/076,370, filed on Feb. 27, 1998.

(51) **Int. Cl.**[7] **B32B 5/14**; B32B 5/18; H05K 9/00

(52) **U.S. Cl.** **428/457**; 361/818

(58) **Field of Search** 428/457; 361/818

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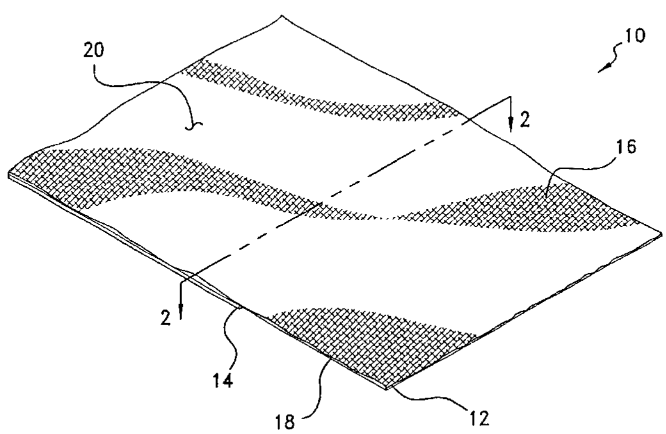
Primary Examiner—Erma Cameron
(74) *Attorney, Agent, or Firm*—John A. Molnar, Jr.

(57) **ABSTRACT**

A flame retardant, electromagnetic interference (EMI) shielding gasket construction. The construction includes a resilient core member formed of a foamed elastomeric material, an electrically-conductive fabric member surrounding the outer surface of the core member, and a flame retardant layer coating at least a portion of the interior surface of the fabric member. The flame retardant layer is effective to afford the gasket construction with a flame class rating of V-0 under Underwriter's Laboratories (UL) Standard No. 94.

9 Claims, 3 Drawing Sheets



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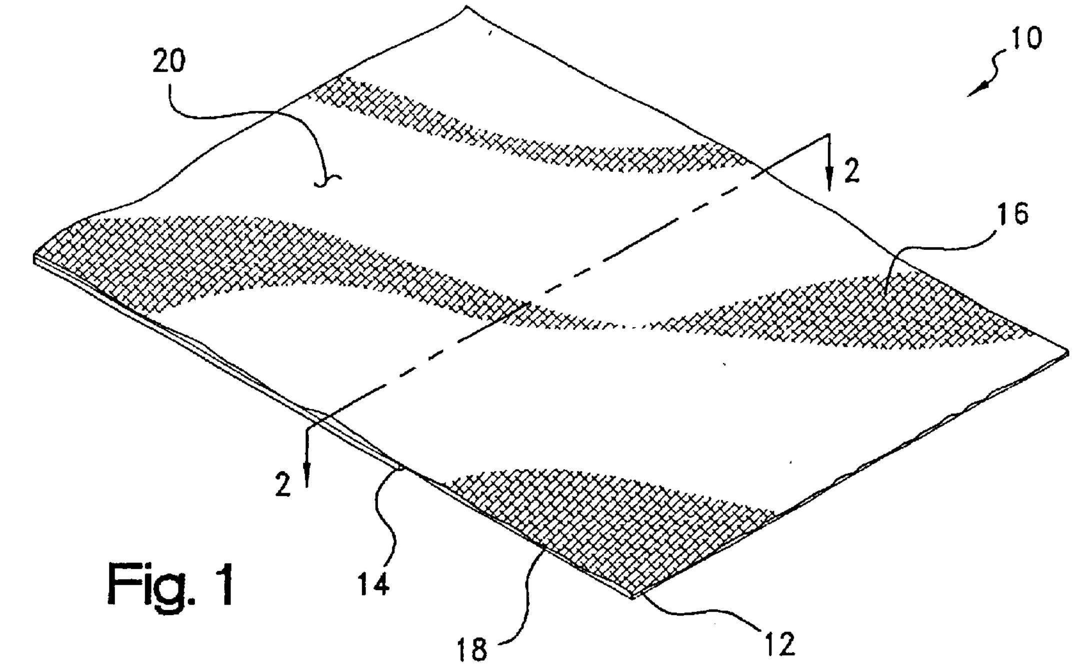

Fig. 1

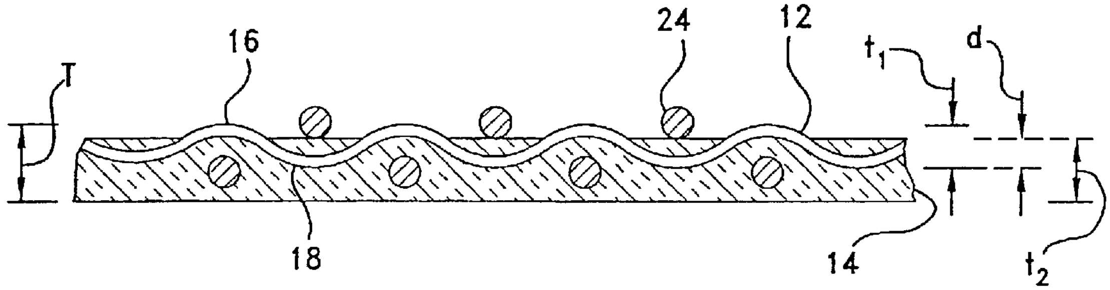

Fig. 2

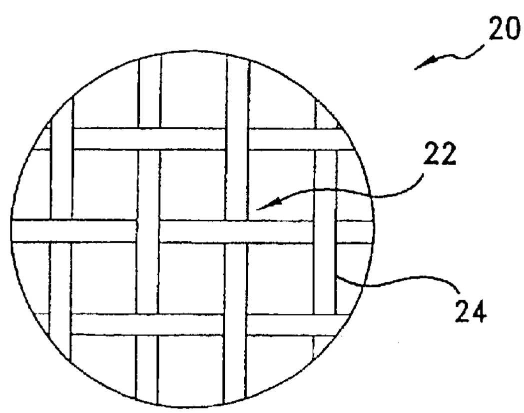

Fig. 3

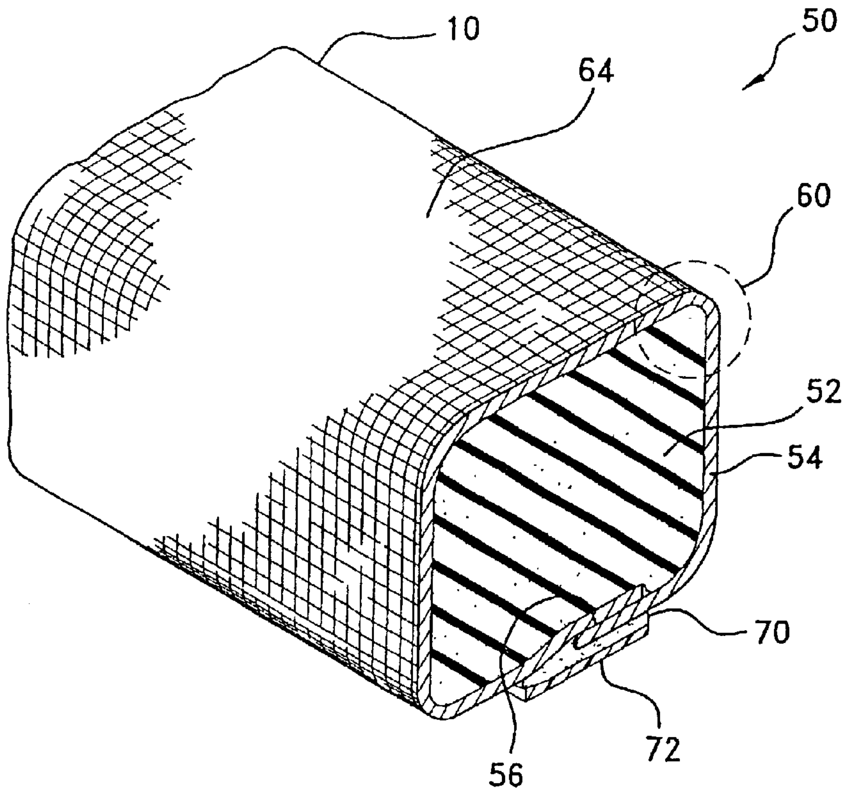

Fig. 4

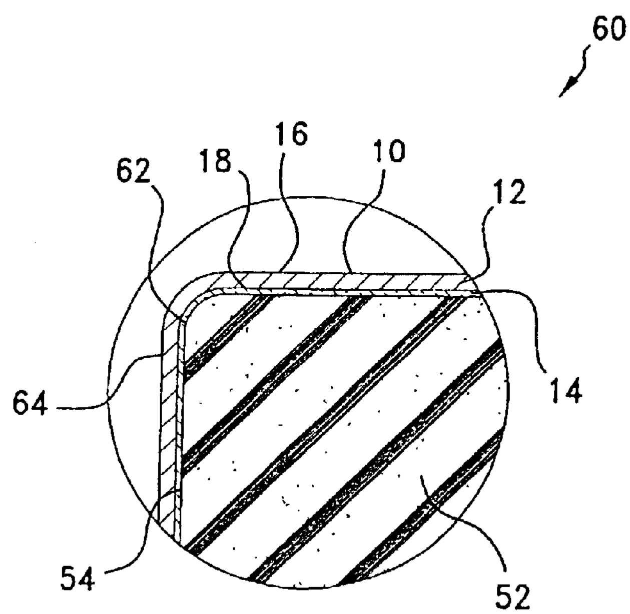

Fig. 5

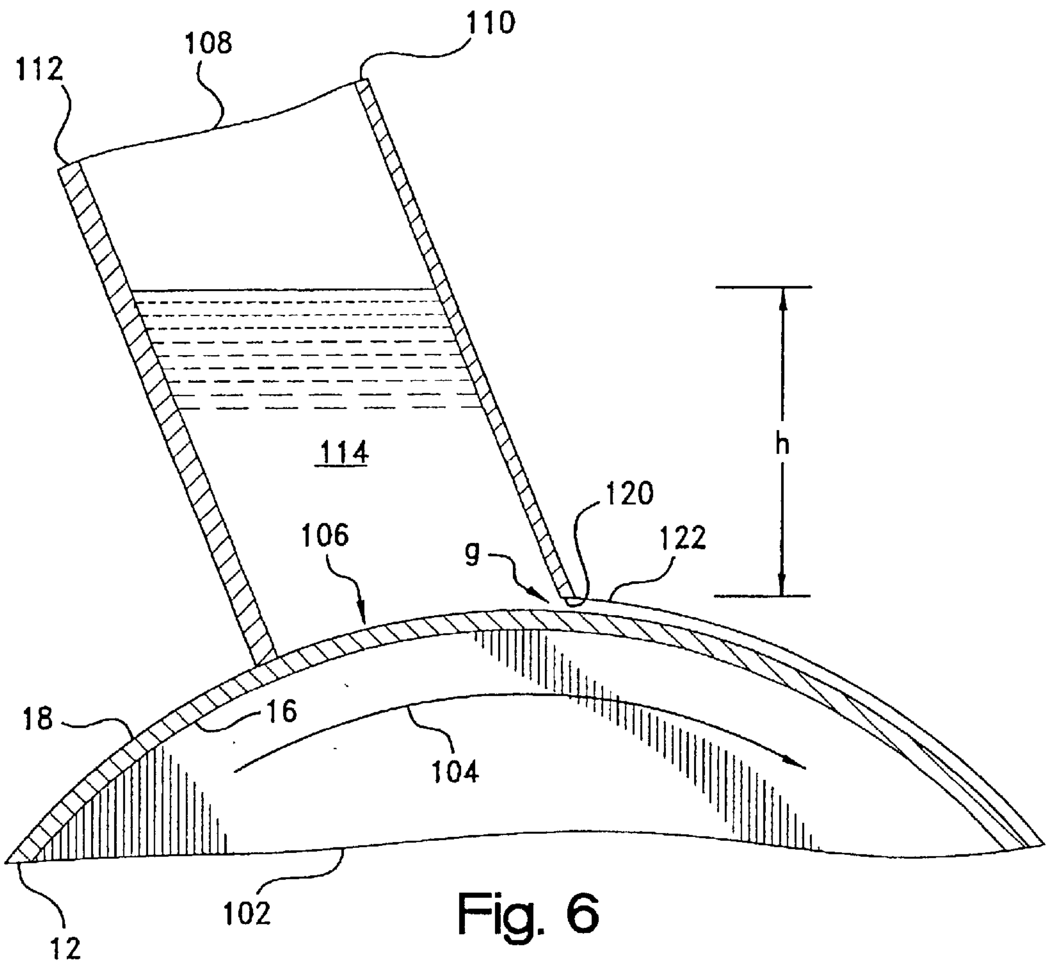

Fig. 6

FLAME RETARDANT EMI SHIELDING GASKET

CROSS-REFERENCE TO RELATED APPLICATION

This application is a continuation of U.S. application Ser. No. 10/142,803 filed May 9, 2002, now U.S. Pat. No. 6,521,348, which is a continuation of U.S. application Ser. No. 09/883,785, filed Jun. 18, 2001, now U.S. Pat. No. 6,387,523; which is a continuation of U.S. application Ser. No. 09/250,338, filed Feb. 16, 1999, now U.S. Pat. No. 6,248,393 and claiming priority to U.S. provisional application Ser. No. 60/076,370, filed Feb. 27, 1998, the disclosure of each of which is expressly incorporated herein by reference.

BACKGROUND OF THE INVENTION

The present invention relates broadly to electrically-conductive, flame retardant materials for use in electromagnetic interference (EMI) shielding, and to a method of manufacturing the same, and more particularly to an electrically-conductive fabric having a layer of a flame retardant coating applied to one surface thereof for use as a sheathing within an EMI shielding gasket.

The operation of electronic devices including televisions, radios, computers, medical instruments, business machines, communications equipment, and the like is attended by the generation of electromagnetic radiation within the electronic circuitry of the equipment. Such radiation often develops as a field or as transients within the radio frequency band of the electromagnetic spectrum, i.e., between about 10 KHz and 10 GHz, and is termed "electromagnetic interference" or "EMI" as being known to interfere with the operation of other proximate electronic devices.

To attenuate EMI effects, shielding having the capability of absorbing and/or reflecting EMI energy may be employed both to confine the EMI energy within a source device, and to insulate that device or other "target" devices from other source devices. Such shielding is provided as a barrier which is inserted between the source and the other devices, and typically is configured as an electrically conductive and grounded housing which encloses the device. As the circuitry of the device generally must remain accessible for servicing or the like, most housings are provided with openable or removable accesses such as doors, hatches, panels, or covers. Between even the flattest of these accesses and its corresponding mating or faying surface, however, there may be present gaps which reduce the efficiency of the shielding by presenting openings through which radiant energy may leak or otherwise pass into or out of the device. Moreover, such gaps represent discontinuities in the surface and ground conductivity of the housing or other shielding, and may even generate a secondary source of EMI radiation by functioning as a form of slot antenna. In this regard, bulk or surface currents induced within the housing develop voltage gradients across any interface gaps in the shielding, which gaps thereby function as antennas which radiate EMI noise. In general, the amplitude of the noise is proportional to the gap length, with the width of the gap having a less appreciable effect.

For filling gaps within mating surfaces of housings and other EMI shielding structures, gaskets and other seals have been proposed both for maintaining electrical continuity across the structure, and for excluding from the interior of the device such contaminates as moisture and dust. Such seals are bonded or mechanically attached to, or press-fit

into, one of the mating surfaces, and function to close any interface gaps to establish a continuous conductive path thereacross by conforming under an applied pressure to irregularities between the surfaces. Accordingly, seals intended for EMI shielding applications are specified to be of a construction which not only provides electrical surface conductivity even while under compression, but which also has a resiliency allowing the seals to conform to the size of the gap. The seals additionally must be wear resistant, economical to manufacture, and capability of withstanding repeated compression and relaxation cycles. For further information on specifications for EMI shielding gaskets, reference may be had to Severinsen, J., "Gaskets That Block EMI," Machine Design, Vol. 47, No. 19, pp. 74–77 (Aug. 7, 1975).

Requirements for typical EMI shielding applications often dictate a low impedance, low profile gasket which is deflectable under normal closure force loads. Other requirements include low cost and a design which provides an EMI shielding effectiveness for both the proper operation of the device and compliance, in the United States, with commercial Federal Communication Commission (FCC) EMC regulations.

A particularly economical gasket construction, which also requires very low closure forces, i.e. less than about 1 lb/inch (0.175 N/mm), is marketed by the Chomerics Division of Parker-Hannifin Corp., Woburn, Mass. under the tradename "Soft-Shield® 5000 Series." Such construction consists of an electrically-conductive jacket or sheathing which is "cigarette" wrapped lengthwise over a polyurethane or other foam core. As is described further in U.S. Pat. No. 4,871,477, polyurethane foams generally are produced by the reaction of polyisocyanate and a hydroxyl-functional polyol in the presence of a blowing agent. The blowing agent effects the expansion of the polymer structure into a multiplicity of open or closed cells.

The jacket is provided as a highly conductive, i.e., about 1 Ω-sq., nickel-plated-silver, woven rip-stop nylon which is self-terminating when cut. Advantageously, the jacket may be bonded to the core in a continuous molding process wherein the foam is blown or expanded within the jacket as the jacket is wrapped around the expanding foam and the foam and jacket are passed through a die and into a traveling molding. Similar gasket constructions are shown in commonly-assigned U.S. Pat. No. 5,028,739 and in U.S. Pat. Nos. 4,857,668; 5,054,635; 5,105,056; and 5,202,536.

Many electronic devices, including PC's and communication equipment, must not only comply with certain FCC requirements, but also must meet be approved under certain Underwriter's Laboratories (UL) standards for flame retardancy. In this regard, if each of the individual components within an electronic device is UL approved, then the device itself does not require separate approval. Ensuring UL approval for each component therefore reduces the cost of compliance for the manufacturer, and ultimately may result in cheaper goods for the consumer. For EMI shielding gaskets, however, such gaskets must be made flame retardant, i.e., achieving a rating of V-0 under UL Std. No. 94, "Tests for Flammability of Plastic Materials for Parts in Devices and Appliances" (1991), without compromising the electrical conductivity necessary for meeting EMI shielding requirements.

In this regard, and particularly with respect to EMI shielding gaskets of the above-described fabric over foam variety, it has long been recognized that foamed polymeric materials are flammable and, in certain circumstances, may

present a fire hazard. Owing to their cellular structure, high organic content, and surface area, most foam materials are subject to relatively rapid decomposition upon exposure to fire or high temperatures.

One approach for imparting flame retardancy to fabric over foam gaskets has been to employ the sheathing as a flame resistant protective layer for the foam. Indeed, V-0 rating compliance purportedly has been achieved by sheathing the foam within an electrically-conductive Ni/Cu-plated fabric to which a thermoplastic sheet is hot nipped or otherwise fusion bonding to the underside thereof. Such fabrics, which may be further described in one or more of U.S. Pat. Nos. 4,489,126; 4,531,994; 4,608,104; and/or 4,621,013, have been marketed by Monsanto Co., St. Louis, under the tradename "Flectron® Ni/Cu Polyester Taffeta V0."

Other fabric over foam gaskets, as is detailed in U.S. Pat. No. 4,857,668, incorporate a supplemental layer or coating applied to the interior surface of the sheath. Such coating may be a flame-retardant urethane formulation which also promotes the adhesion of the sheath to the foam. The coating additionally may function to reduce bleeding of the foam through the fabric which otherwise could compromise the electrical conductivity of the sheath.

In view of the foregoing, it will be appreciated that further improvements in the design of flame retardant, fabric-over foam EMI shielding gaskets, as well as sheathing materials therefore, would be well-received by the electronics industry. Especially desired would be a flame retardant gasket construction which achieves a UL94 rating of V-0.

BROAD STATEMENT OF THE INVENTION

The present invention is directed to an electrically-conductive, flame retardant material for use in fabric-over-foam EMI shielding gaskets, and to a method of manufacturing the same. In having a layer of a flame retardant coating applied to one side of an electrically-conductive, generally porous fabric, the material of the invention affords UL94 V-0 protection when used as a jacketing in a fabric-over-foam gasket construction. Advantageously, as the flame retardant layer may be wet coated on the fabric without appreciable bleed through, a relatively thin, i.e., 2–4 mil (0.05–0.10 mm), coating layer may be provided on one fabric side without compromising the electrical surface conductivity of the other side. Such a thin coating layer, while being sufficient to provide UL94 V-0 protection, nonetheless maintains the drapability the fabric and thereby facilitates the construction UL94 V-0 compliant gaskets having complex profiles or narrow cross-sections down to about 1 mm.

In a preferred embodiment, the electrically-conductive, flame retardant EMI shielding material of the invention includes a nickel or silver-plated, woven nylon, polyester, or like fabric on one side of which is wet coated a layer of a flame retardant, acrylic latex emulsion or other fluent resin composition. In accordance with the precepts of the method of the invention, the viscosity and hydrodynamic pressure of the emulsion are controlled such that the coating does not penetrate or otherwise "bleed through" the uncoated side of the fabric. The surface conductivity of the opposite side of the fabric therefore is not compromised in EMI shielding applications.

The material of the invention may be employed as a jacket in fabric-over-foam EMI shielding gasket constructions, and is particularly adapted for use in the continuous molding process for such gaskets. As used within such process, the fabric may be wrapped around the foam as a jacket with coated side thereof being disposed as an interior surface adjacent the foam, and the uncoated side being disposed as an electrically-conductive exterior surface. Advantageously, the coating on the interior surface of the jacket blocks the pores of the fabric to retain the foam therein without penetrate or bleed through to the exterior surface. In being formed of a acrylic material, the coated interior surface of the jacket may function, moreover, depending upon the composition of the foam, as a compatibilizing or "tie" interlayer which promotes the bonding of the foam to the fabric.

The present invention, accordingly, comprises material and method possessing the construction, combination of elements, and arrangement of parts and steps which are exemplified in the detailed disclosure to follow. Advantages of the present invention include a flame retardant yet drapable EMI shielding fabric. Additional advantages include an economical, flame retardant EMI shielding fabric construction wherein a relatively thin layer of a flame retardant coating may be wet coated onto one side of an electrically-conductive, woven or other generally porous EMI shielding fabric without compromising the conductivity of the other side of the fabric. These and other advantages will be readily apparent to those skilled in the art based upon the disclosure contained herein.

BRIEF DESCRIPTION OF THE DRAWINGS

For a fuller understanding of the nature and objects of the invention, reference should be had to the following detailed description taken in connection with the accompanying drawings wherein:

FIG. **1** is a perspective view of one embodiment of an EMI shielding material according to the present invention which material includes a generally planar fabric member on one side of which is coated a layer of a flame retardant composition, the view being shown with portions being broken away to better reveal the structure of the material;

FIG. **2** is an enlarged cross-sectional view of the EMI shielding material of FIG. **1** taken through plane represented by line **2**—**2** of FIG. **1**;

FIG. **3** is a top view of the material of FIG. **1** which is magnified to reveal the structure of the fabric member thereof;

FIG. **4** is a perspective cross-sectional view of a length of a representative EMI shielding gasket construction according to the present invention including a jacket which is formed of the EMI shielding material of FIG. **1**;

FIG. **5** is an end view of the gasket of FIG. **4** which is magnified to reveal the structure thereof, and

FIG. **6** is a schematic, partially cross-sectional view of an illustrative gravity-fed, knife over roll coater as adapted for use in the manufacture of the EMI shielding material of FIG. **1**.

The drawings will be described further in connection with the following Detailed Description of the Invention.

DETAILED DESCRIPTION OF THE INVENTION

Certain terminology may be employed in the description to follow for convenience rather than for any limiting purpose. For example, the terms "upper" and "lower" designate directions in the drawings to which reference is made, with the terms "inner" or "interior" and "outer" or "exterior" referring, respectively, to directions toward and away from

the center of the referenced element, and the terms "radial" and "axial" referring, respectively, to directions perpendicular and parallel to the longitudinal central axis of the referenced element. Terminology of similar import other than the words specifically mentioned above likewise is to be considered as being used for purposes of convenience rather than in any limiting sense.

For the illustrative purposes of the discourse to follow, the electromagnetic interference (EMI) shielding material herein involved is described in connection with its use as a flame retardant, electrically-conductive jacket for a foam core, EMI shielding gasket as may be adapted to be received within an interface, such as between a door, panel, hatch, cover, or other parting line of an electromagnetic interference (EMI) shielding structure. The EMI shielding structure may be the conductive housing of a computer, communications equipment, or other electronic device or equipment which generates EMI radiation or is susceptible to the effects thereof. The gasket may be bonded or fastened to, or press-fit into one of a pair of mating surfaces which define the interface within the housing, and functions between the mating surfaces to seal any interface gaps or other irregularities. That is, while under an applied pressure, the gasket resiliently conforms to any such irregularities both to establish a continuous conductive path across the interface, and to environmentally seal the interior of the housing against the ingress of dust, moisture, or other contaminates. It will be appreciated, however, that aspects of the present invention may find utility in other EMI shielding applications. Use within those such other applications therefore should be considered to be expressly within the scope of the present invention.

Referring then to the figures, wherein corresponding reference characters are used to designate corresponding elements throughout the several views, a flame retardant EMI shielding material according to the present invention is shown generally at **10** in FIG. **1** as generally adapted for use as a jacket within for a foam core gasket construction. For purposes of illustration, material sheet **10** is shown to be of indefinite dimensions which may be cut to size for the particular application envisioned. In basic construction, material **10** includes an upper, generally planar and porous fabric member, **12**, and a lower, flame retardant coating member, **14**.

Fabric member has at least an electrically-conductive first side, **16**, and a conductive or non-conductive second side, **18**, defining a thickness dimension, referenced at "t," in the cross-sectional view of FIG. **2**, which may vary from about 2–4 mils (0.05–0.10 mm). By "electrically-conductive," it is meant that the fabric may be rendered conductive, i.e., to a surface resistivity of about 0.1 Ω/sq. or less, by reason of its being constructed of electrically-conductive wire, monofilaments, yarns or other fibers or, alternatively, by reason of a treatment such as a plating or sputtering being applied to non-conductive fibers to provide an electrically-conductive layer thereon. Preferred electrically-conductive fibers include Monel nickel-copper alloy, silver-plated copper, nickel-clad copper, Ferrex® tin-plated copper-clad steel, aluminum, tin-clad copper, phosphor bronze, carbon, graphite, and conductive polymers. Preferred non-conductive fibers include cotton, wool, silk, cellulose, polyester, polyamide, nylon, and polyimide monofilaments or yarns which are rendered electrically conductive with a metal plating of copper, nickel, silver, nickel-plated-silver, aluminum, tin, or an alloy thereof. As is known, the metal plating may applied to individual fiber strands or to the surfaces of the fabric after weaving, knitting, or other fabrication.

While fabrics such as wire meshes, knits, and non-woven cloths and webs may find application, a preferred fabric construction for member **12** is a plain weave nylon or polyester cloth which is made electrically conductive with between about 20–40% by weight based on the total fabric weight, i.e., 0.01–0.10 g/in^2, of a silver, nickel-silver, or silver-nickel over copper plating. As may be seen in the magnified view of FIG. **1** referenced at **20** in FIG. **3**, such cloth is permeable in having a plain, generally square weave pattern with pores or openings, one of which is referenced at **22**, being defined between the fibers which are represented schematically at **24**. Fibers **24** may be yarns, monofilaments or, preferably, bundles of from about 10–20 filaments or threads, each having a diameter of between about 10–50 μm. For example, with fibers **24** each being a bundle of such threads with a thread count of between about 1000–3000 per inch and a weave count of between about 1000–1500 per inch, 1000–2000 openings per inch will be defined with a mean average pore size of between about 0.5–2 mils (12.5–50 μm).

Although a plain, square weave pattern such as a taffeta, tabby, or ripstop is considered preferred, other weaves such as satins, twills, and the like also should be considered within the scope of the invention herein involved. A particularly preferred cloth for fabric member **12** is a 4 mil (0.10 mm) thick, 1.8 oz/yd^2 weight, silver-plated, woven nylon which is marketed commercially under the designation "31EN RIPSTOP" by Swift Textile Metalizing Corp., Bloomfield, Conn. However, depending upon the needs of the specific shielding application, a fabric constructed of a combination or blend of conductive and nonconductive fibers alternatively may be employed. Examples of fabrics woven, braided, or warp knitted from electrically-conductive fibers, or from blends of conductive and non-conductive fibers, are described in Gladfelter, U.S. Pat. No. 4,684,762, and in Buonanno, U.S. Pat. No. 4,857,668.

Returning to FIGS. **1** and **2**, coating member **14** preferably is formed from a curable layer of a fluent, flame retardant resin or other composition which is wet coated onto the second side **18** of fabric member **12**. As is detailed hereinafter, the viscosity and hydrodynamic pressure of the resin composition are controlled in accordance with the precepts of the present invention to delimit the penetration of the resin layer to a depth, referenced at "d" in FIG. **2**, which is less than the thickness dimension t_1 of the fabric member **12**. In this regard, when the layer is cured to form the flame retardant surface coating member **14** on the second side **18** of fabric member **12**, the first side **16** thereof remains electrically-conductive. In a preferred construction, the layer is coated to a wet thickness of about 10 mils (0.25 mm), and then cured to a dried coating or film thickness, referenced at t_2 in FIG. **2**, of between about 2–4 mils (0.05–0.10 mm) at a depth d of about 1–2 mils (0.025–0.05 mm). Ultimately, a total material thickness, referenced at "T," of between about 6–7 mils (0.15–0.20 mm) and a dried weight pickup of between about 100–150 g/yd^2 are observed. By "cured" it is meant that the resin is polymerized, cross-linked, further cross-linked or polymerized, vulcanized, hardened, dried, volatilized, or otherwise chemically or physically changed from a liquid or other fluent form into a solid polymeric or elastomeric phase.

The flame retardant composition preferably is formulated as an aqueous emulsion of an acrylic latex emulsion which is adjusted to a total solids of about 60% and a Brookfield viscosity (#5 spindle, 4 speed) of between about 40,000–60,000 cps, at a density of about 10 lbs per gallon (1.8 g/cm^3). Flame retardancy may be imparted by loading the emulsion

with between about 30–50% by weight of one or more conventional flame retardant additives such as aluminum hydrate, antimony trioxide, phosphate esters, or halogenated compounds such as polybrominated diphenyl oxides. A preferred formulation is a mixture of about 25% by weight, based on the total weight of the emulsion, of decambromodiphenyl oxide and about 15% by weight of one or more antimony compounds. In operation, should the acrylic carrier phase be ignited, the decomposition of the halogenated and metal oxide compounds function to chemically deprive the flame of sufficient oxygen to support combustion. The decomposition of the acrylic phase additionally may lead to the development of a protective, i.e., thermally-insulative or refractory, outer char layer.

A preferred flame retardant, acrylic latex emulsion is marketed commercially by Heveatex Corp., Fall River, Mass., under the designation "4129FR." The viscosity of the emulsion may be adjusted to between about 40,000–60,000 cps using an aqueous acryloid gel or other acrylic thickener. In this regard, the increased viscosity of the emulsion contributes to delimiting the penetration of the coating layer into the fabric member. However, as this relatively high viscosity may lead to undesirable porosity in the dried film, the emulsion additionally may be modified to reduce air entrapment and bubble formation in the coating layer with up to about 1% by weight of one or more commercial surfactants such as "Bubble Breaker" by Witco Chemical Corp. (Chicago, Ill.) and "Foam Master Antifoam" by Diamond Shamrock, Inc. (San Antonio, Tex.).

As aforementioned, EMI shielding material **10** of the present invention is particularly adapted for use as a flame retardant, electrically-conductive jacket which is provided over a foam core in an EMI shielding gasket construction such as gasket **50** of FIG. **4**. In a representative embodiment, gasket **50** includes an elongate, resilient foam core member, **52**, which may be of an indefinite length. Core member **52** has an outer circumferential surface, **54**, defining the cross-sectional profile of gasket **50** which, for illustrative purposes, is of a generally polygonal, i.e., square or rectangular geometry. Other plane profiles, such as circular, semi-circular, or elliptical, or complex profiles may be substituted, however, depending upon the geometry of the interface to be sealed. Core member **12** may be of any radial or diametric extent, but for most applications will have a diametric extent or width of from about 0.25 inch (0.64 cm) to 1 inch (2.54 cm).

For affording gap-filling capabilities, it is preferred that core member **52** is provided to be complaint over a wide range of temperatures, and to exhibit good compression-relaxation hysteresis even after repeated cyclings or long compressive dwells. Core member **52** therefore may be formed of a foamed elastomeric thermoplastic such as a polyethylene, polypropylene, polypropylene-EPDM blend, butadiene, styrene-butadiene, nitrile, chlorosulfonate, or a foamed neoprene, urethane, or silicone. Preferred materials of construction include open or closed cell urethanes or blends such as a polyolefin resin/monoolefin copolymer blend, or a neoprene, silicone, or nitrile sponge rubber.

Core member **52** may be provided as an extruded or molded foam profile over which shielding material **10** is wrapped as a sheathed, with the edges of sheathed being overlapped as at **56**. In a preferred construction, shielding material **10** is bonded to the core member **52** in a continuous molding process wherein the foam is blown or expanded within the shielding material. As may be seen best with reference to the magnified view of FIG. **4** referenced at **60** in FIG. **5**, in such construction coating member **14** is

disposed adjacent core member **52** as an interior surface, **62**, of shielding member **10**, with the uncoated side **16** of fabric member **12** being oppositely disposed as an electrically-conductive exterior surface, **64**, of the gasket **50**. It will be appreciated that the coated interior surface **62** blocks the pores **22** (FIG. **3**) of the fabric member **12** of the fabric to retain the blown foam therein without penetrate or bleed through to the exterior gasket surface **64**. Depending upon the respective compositions of the foam and coating, the interior surface **62** may function, moreover, as a compatibilizing or "tie" interlayer which promotes the bonding of the foam to the fabric. Gasket construction **50** advantageously provides a structure that may be used in very low closure force, i.e. less than about 1 lb/inch (0.175 N/mm), applications.

Referring again to FIG. **4**, an adhesive layer, **70**, may be applied along the lengthwise extent of gasket **50** to the underside of exterior surface **64** for the attachment of the gasket to a substrate. Such layer **70** preferably is formulated to be of a pressure sensitive adhesive (PSA) variety. As is described in U.S. Pat. No. 4,988,550, suitable PSA's for EMI shielding applications include formulations based on silicones, neoprene, styrene butadiene copolymers, acrylics, acrylates, polyvinyl ethers, polyvinyl acetate copolymers, polyisobutylenes, and mixtures, blends, and copolymers thereof. Acrylic-based formulations, however, generally are considered to be preferred for the EMI applications of the type herein involved. Although PSA's are preferred for adhesive layer **70**, other adhesives such as epoxies and urethanes may be substituted and, accordingly, are to be considered within the scope of the present invention. Heat-fusible adhesives such a hot-melts and thermoplastic films additionally may find applicability.

Inasmuch as the bulk conductivity of gasket **50** is determined substantially through its surface contact with the substrate, an electrically-conductive PSA may be preferred to ensure optimal EMI shielding performance. Such adhesives conventionally are formulated as containing about 1–25% by weight of a conductive filler to yield a volume resistivity of from about 0.01–0.001 Ω-cm. The filler may be incorporated in the form of particles, fibers, flakes, microspheres, or microballoons, and may range in size of from about 1–100 microns. Typically filler materials include inherently conductive material such as metals, carbon, and graphite, or nonconductive materials such as plastic or glass having a plating of a conductive material such as a noble metal or the like. In this regard, the means by which the adhesive is rendered electrically conductive is not considered to be a critical aspect of the present invention, such that any means achieving the desired conductivity and adhesion are to be considered suitable.

For protecting the outer portion of adhesive layer **70** which is exposed on the exterior surface of the gasket, a release sheets, shown at **72**, may be provided as removably attached to the exposed adhesive. As is common in the adhesive art, release sheet **72** may be provided as strip of a waxed, siliconized, or other coated paper or plastic sheet or the like having a relatively low surface energy so as to be removable without appreciable lifting of the adhesive from the exterior surface **64**.

In the production of commercial quantities of the EMI shielding material **10** of the present invention, the viscosity adjusted and otherwise modified acrylic latex emulsion or other resin composition may be coated and cured on one side the fabric member **12** by a direct wet process such as knife over roll or slot die. With whatever process is employed, the hydrodynamic pressure of the resin composition is con-

trolled in accordance with the precepts of the present invention to delimit the penetration of the resin layer to a depth which is less than the thickness dimension of the fabric member. For example, and with reference to FIG. **6** wherein the head of a representative gravity-fed knife over roll coater is shown somewhat schematically at **100**, porous, i.e., permeable, fabric member **12** is conveyed from a feed roll or the like (not shown) over a nip roller, **102**, which rotates in the direction referenced by arrow **104**. With the first side **16** of fabric member **12** supported on roller **102**, the fabric second side **18** is passed beneath the opening, referenced at **106**, of a coating trough, **108**. Trough **108** is defined by a front plate, **110**, a back plate, **112**, and a pair of side plates (not shown).

The emulsion or other fluent resin composition, referenced at **114**, is pumped or otherwise transported into trough **108** which is filled to a fluid level, referenced at h. For a given fluid density, this level h is controlled such that the hydrodynamic pressure at the fabric-liquid interface is maintained within preset limits. For example, with a fluid density of about 10 pounds per gallon (1.8 g/cm^3), and a fabric having a porosity of about 1000–2000 openings per inch with a mean average pore size of between about 0.5–2 mils (12.5–50 μm), the fluid level H is controlled at about 4 inches (10 cm) to yield a hydrodynamic pressure of about 0.05 psi (0.35 kPa) at the fabric-liquid interface. For other coating processes, the hydrodynamic fluid pressure may be controlled, for example, by a pumping pressure or the like.

In the illustrative knife-over-roll coating process, the lower edge, **120**, of front plate **110** defines a knife surface which is shimmed or otherwise spaced-apart a predetermined distance from the second side **18** of fabric member **12**. Such spacing provides a clearance or gap, referenced at "g," of typically about 10 mils (0.25 mm), but which is adjustable to regulate the thickness of the liquid coating layer, **122**, being applied to the fabric member. From roller **104**, the coated fabric member **12** may be conveyed via a take-up roller arrangement (not shown) through a in-line oven or the like to dry or flash the water or other diluent in the liquid coating layer **122**, or to otherwise cure the liquid coating layer **122** in developing an adherent, tack-free, film or other layer of coating member **14** (FIG. **1**) on the single side **18** of fabric member **12**.

The Example to follow, wherein all percentages and proportions are by weight unless otherwise expressly indicated, is illustrative of the practicing of the invention herein involved, but should not be construed in any limiting sense.

EXAMPLE

Representative EMI shielding materials according to the present invention were constructed for characterization. In this regard, a master batch of a flame retardant coating composition was compounded using an acrylic latex emulsion (Heveatex "4129FR"). The viscosity of the emulsion was adjusted to a Brookfield viscosity (#4 spindle, 40 speed) of about 60,000 cps with about 5 wt % of an acryloid thickener (Acrysol™ GS, Monsanto Co., St. Louis, Mo.). The modified emulsion had a total solids content of about 60% by weight, a density of about 10 pounds per gallon (1.8 g/cm^3), and a pH of between about 7.5 and 9.5.

The emulsion was applied using a knife over roll coater (JETZONE Model 7319, Wolverine Corp., Merrimac, Mass.) to one side of a silver-plated nylon fabric (Swift "31EN RIPSTOP") having a thickness of about 4 mils (0.1 mm). With the fluid level in the coating trough of the coater maintained at about 4 inch (10 cm), the emulsion was delivered to the surface of the cloth at a hydrodynamic pressure of about 0.05 psi (0.35 kPa). The coating knife was shimmed to a 10 mil (0.25 mm) gap above the fabric to yield a wet coating draw down thickness of about 10 mils. Following an oven curing at 100–125° C. for 5 minutes, a dried coating or film thickness of about 2.5 mils (0.635 mm) was obtained with a weight pickup of about 130–145 g/yd^2 and a total material thickness of between about 6–7 mils (0.15–0.18 mm). An inspection of the coated fabric cloth revealed a coating penetration depth of about 1–2 mils (0.02–0.05 mm) providing acceptable mechanical retention and/or adhesion of the coating onto the fabric surface. The opposite side of the fabric, however, was observed to be substantially coating free, and to retain a surface resistivity of about 0.1 Ω/sq for unaffected EMI shielding effectiveness.

Fabric samples similarly coated in the manner described were subjected to an in-house vertical flame test. No burning was observed at dried film thickness of 2, 3, or 4 mils (0.05, 0.08, 0.10 mm). Accordingly, a reasonable operating window of film thickness was suggested for production runs.

Samples also were provided, as jacketed over a polyurethane foam core in an EMI shielding gasket construction, for flame testing by Underwriters Laboratories, Inc., Melville, N.Y. A flame class rating of V-0 under UL94 was assigned at a minimum thickness of 1.0 mm. The gasket construction therefore was found to be compliant with the applicable UL requirements, and was approved to bear the "UL" certification mark.

The foregoing results confirm that, the EMI shielding material of the present invention affords UL94 V-0 protection when used as a jacketing in a fabric-over-foam gasket construction. Unexpectedly, it was found that a relatively porous or permeable fabric may be wet coated on one side with a relatively thin, i.e., 2–4 mil (0.05–0.10 mm), coating layer of a flame retardant composition without compromising the electrical surface conductivity of the other side. Such a thin coating layer, while being sufficient to provide UL94 V-0 protection in a conventional fabric-over-foam gasket construction, nonetheless maintains the drapability the fabric and thereby facilitates the fabrication of UL94 V-0 compliant gaskets having complex profiles or narrow cross-sections down to about 1 mm.

As it is anticipated that certain changes may be made in the present invention without departing from the precepts herein involved, it is intended that all matter contained in the foregoing description shall be interpreted as illustrative and not in a limiting sense. All references cited herein are expressly incorporated by reference.

What is claimed is:

1. A flame retardant, electromagnetic interference (EMI) shielding gasket comprising:

a resilient core member extending lengthwise along a central longitudinal axis and having an outer surface extending circumferentially about said longitudinal axis, said core member being formed of a foamed elastomeric material;

an electrically-conductive fabric member surrounding the outer surface of said core member, said fabric member having an interior surface disposed facing the outer surface of said core member and an oppositely-facing, exterior surface, at least the exterior surface being electrically-conductive and the exterior surface defining with the interior surface a thickness dimension of the fabric member therebetween; and

a flame retardant layer coating at least a portion of the interior surface of said fabric member, said flame retardant layer comprising at least about 30% by weight of one or more flame retardant additives and penetrating into said fabric member to a depth which is less than the thickness dimension of said fabric member such that the exterior surface of said fabric member remains electrically-conductive.

2. The gasket of claim **1** wherein said flame retardant layer has a thickness of between about 2–4 mils (0.05–0.10 mm).

3. The gasket of claim **1** wherein said flame retardant layer is formed as a cured film of a flame retardant acrylic latex emulsion.

4. The gasket of claim **1** wherein said fabric member is a metal-plated cloth.

5. The gasket of claim **4** wherein said cloth comprises fibers selected from the group consisting of cotton, wool, silk, cellulose, polyester, polyamide, nylon, and combinations thereof, and said metal is selected from the group

consisting of copper, nickel, silver, nickel-plated-silver, aluminum, tin, and combinations thereof.

6. The gasket of claim **1** wherein said foamed elastomeric material is selected from the group consisting of polyethylenes, polypropylenes, polypropylene-EPDM blends, butadienes, styrene-butadienes, nitriles, chlorosulfonates, neoprenes, urethanes, silicones, and polyolefin resin/monoolefin copolymer blends, and combinations thereof.

7. The gasket of claim **1** wherein said fabric member has a thickness of between about 2–4 mils (0.05–0.10 mm).

8. The gasket of claim **1** wherein said flame retardant layer is effective to afford the gasket a flame class rating of V-0 under Underwriter's Laboratories (UL) Standard No. 94.

9. The gasket of claim **1** wherein said one or more flame retardant additives are selected from the group consisting of aluminum hydrate, antimony trioxide, phosphate esters, and halogenated compounds.

* * * * *

EXHIBIT C

US006777095B2

(12) **United States Patent**
Bunyan et al.

(10) **Patent No.: US 6,777,095 B2**
(45) **Date of Patent: Aug. 17, 2004**

(54) **FLAME RETARDANT EMI SHIELDING GASKET**

(75) Inventors: **Michael H. Bunyan**, Chelmsford, MA (US); **William I. Flanders**, Merimack, NH (US)

(73) Assignee: **Parker-Hannifin Corporation**, Cleveland, OH (US)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

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Related U.S. Application Data

(63) Continuation of application No. 10/318,609, filed on Dec. 11, 2002, now Pat. No. 6,716,536, which is a continuation of application No. 10/142,803, filed on May 9, 2002, now Pat. No. 6,521,348, which is a continuation of application No. 09/883,785, filed on Jun. 18, 2001, now Pat. No. 6,387,523, which is a continuation of application No. 09/250,338, filed on Feb. 16, 1999, now Pat. No. 6,248,393.

(60) Provisional application No. 60/076,370, filed on Feb. 27, 1998.

(51) **Int. Cl.**[7] **B32B 5/14**; B32B 5/18; H05K 9/00

(52) **U.S. Cl.** **428/457**; 361/818

(58) **Field of Search** 428/457; 361/818

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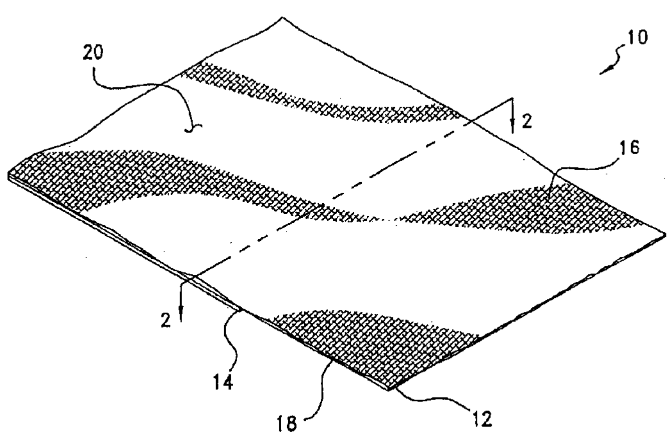
Primary Examiner—Erma Cameron
(74) *Attorney, Agent, or Firm*—John A. Molnar, Jr.

(57) **ABSTRACT**

A flame retardant, electromagnetic interference (EMI) shielding gasket construction. The construction includes a resilient core member formed of a foamed elastomeric material, an electrically-conductive fabric member surrounding the outer surface of the core member, and a flame retardant layer coating at least a portion of the interior surface of the fabric member. The flame retardant layer is effective to afford the gasket construction with a flame class rating of V-0 under Underwriter's Laboratories (UL) Standard No. 94.

10 Claims, 3 Drawing Sheets



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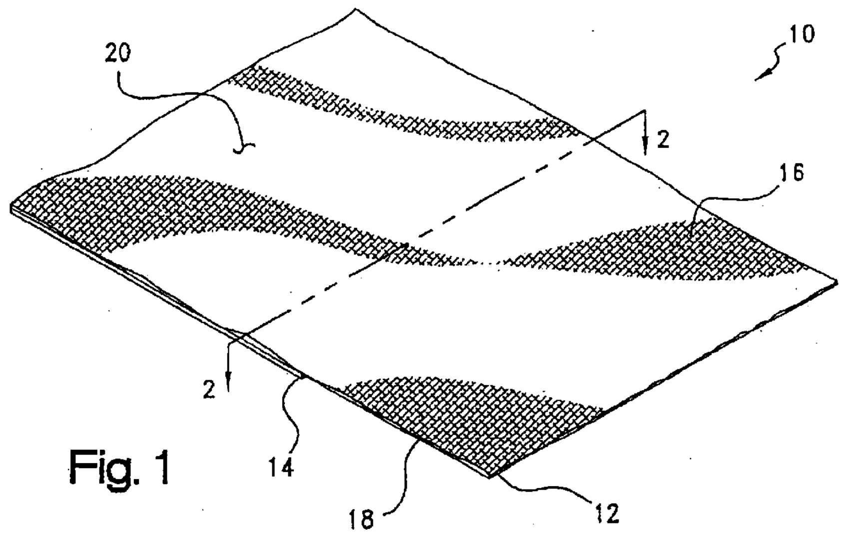

Fig. 1

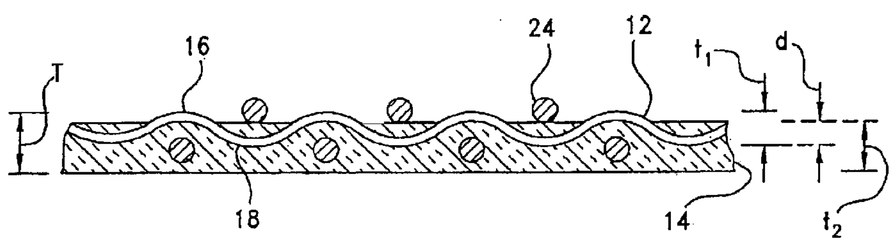

Fig. 2

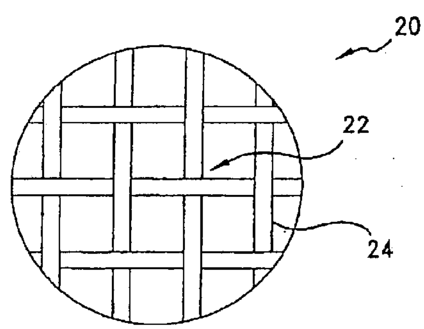

Fig. 3

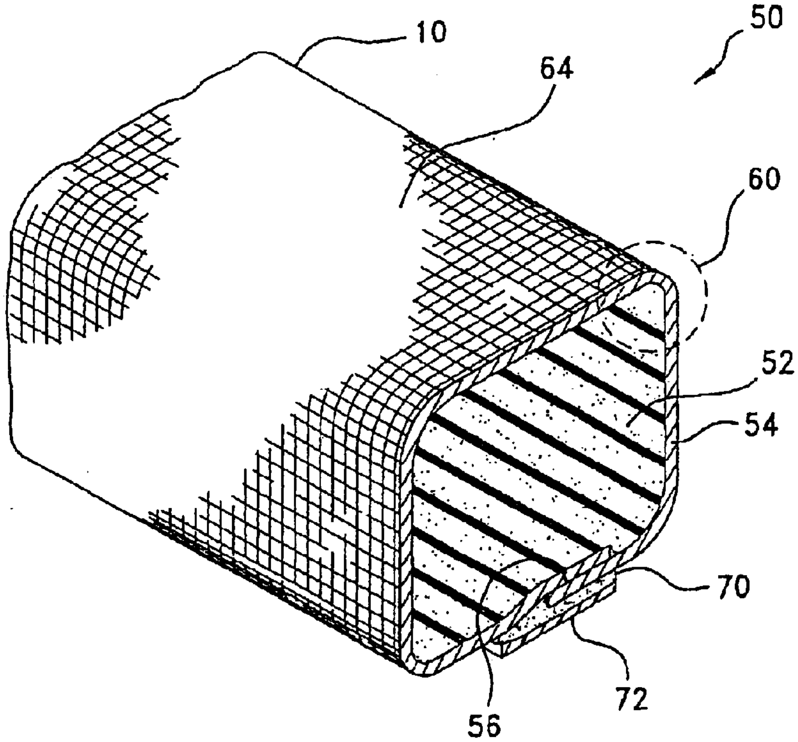

Fig. 4

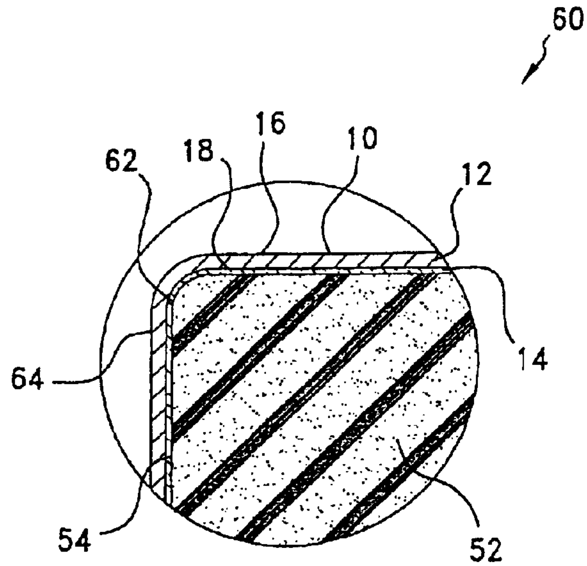

Fig. 5

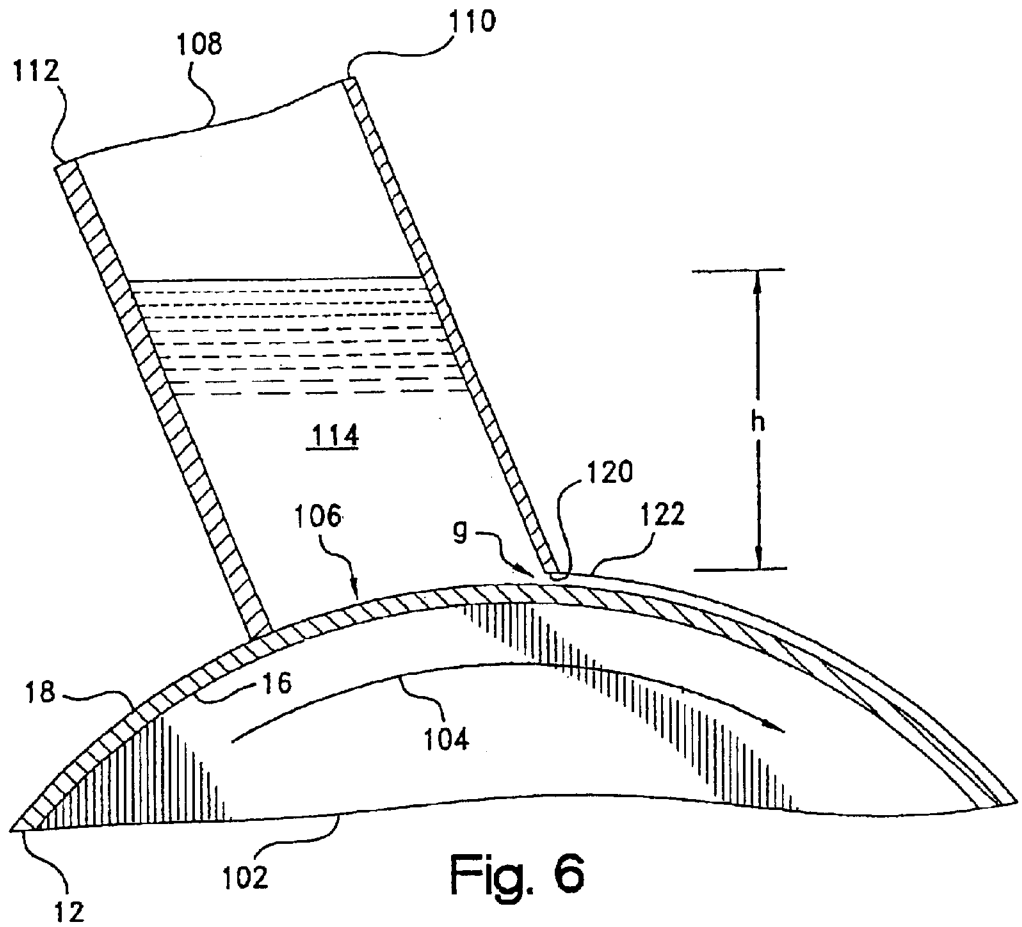

Fig. 6

FLAME RETARDANT EMI SHIELDING GASKET

CROSS-REFERENCE TO RELATED APPLICATION

This application is a continuation of U.S. application Ser. No. 10/318,609, filed Dec. 11, 2002, now U.S. Pat. No. 6,716,536; which is a continuation of U.S. application Ser. No. 10/142,803, filed May 9, 2002, now U.S. Pat. No. 6,521,348; which is a continuation of U.S. application Ser. No. 09/883,785, filed Jun. 18, 2001, now U.S. Pat. No. 6,387,523; which is a continuation of U.S. application Ser. No. 09/250,338, filed Feb. 16, 1999, now U.S. Pat. No. 6,248,393 and claiming priority to U.S. Provisional application Serial No. 60/076,370, filed Feb. 27, 1998, the disclosure of each of which is expressly incorporated herein by reference.

BACKGROUND OF THE INVENTION

The present invention relates broadly to electrically-conductive, flame retardant materials for use in electromagnetic interference (EMI) shielding, and to a method of manufacturing the same, and more particularly to an electrically-conductive fabric having a layer of a flame retardant coating applied to one surface thereof for use as a sheathing within an EMI shielding gasket.

The operation of electronic devices including televisions, radios, computers, medical instruments, business machines, communications equipment, and the like is attended by the generation of electromagnetic radiation within the electronic circuitry of the equipment. Such radiation often develops as a field or as transients within the radio frequency band of the electromagnetic spectrum, i.e., between about 10 KHz and 10 GHz, and is termed "electromagnetic interference" or "EMI" as being known to interfere with the operation of other proximate electronic devices.

To attenuate EMI effects, shielding having the capability of absorbing and/or reflecting EMI energy may be employed both to confine the EMI energy within a source device, and to insulate that device or other "target" devices from other source devices. Such shielding is provided as a barrier which is inserted between the source and the other devices, and typically is configured as an electrically conductive and grounded housing which encloses the device. As the circuitry of the device generally must remain accessible for servicing or the like, most housings are provided with openable or removable accesses such as doors, hatches, panels, or covers. Between even the flattest of these accesses and its corresponding mating or faying surface, however, there may be present gaps which reduce the efficiency of the shielding by presenting openings through which radiant energy may leak or otherwise pass into or out of the device. Moreover, such gaps represent discontinuities in the surface and ground conductivity of the housing or other shielding, and may even generate a secondary source of EMI radiation by functioning as a form of slot antenna. In this regard, bulk or surface currents induced within the housing develop voltage gradients across any interface gaps in the shielding, which gaps thereby function as antennas which radiate EMI noise. In general, the amplitude of the noise is proportional to the gap length, with the width of the gap having a less appreciable effect.

For filling gaps within mating surfaces of housings and other EMI shielding structures, gaskets and other seals have been proposed both for maintaining electrical continuity across the structure, and for excluding from the interior of the device such contaminates as moisture and dust. Such seals are bonded or mechanically attached to, or press-fit into, one of the mating surfaces, and function to close any interface gaps to establish a continuous conductive path thereacross by conforming under an applied pressure to irregularities between the surfaces. Accordingly, seals intended for EMI shielding applications are specified to be of a construction which not only provides electrical surface conductivity even while under compression, but which also has a resiliency allowing the seals to conform to the size of the gap. The seals additionally must be wear resistant, economical to manufacture, and capability of withstanding repeated compression and relaxation cycles. For further information on specifications for EMI shielding gaskets, reference may be had to Severinsen, J., "Gaskets That Block EMI," Machine Design, Vol. 47, No. 19, pp. 74–77 (Aug. 7, 1975).

Requirements for typical EMI shielding applications often dictate a low impedance, low profile gasket which is deflectable under normal closure force loads. Other requirements include low cost and a design which provides an EMI shielding effectiveness for both the proper operation of the device and compliance, in the United States, with commercial Federal Communication Commission (FCC) EMC regulations.

A particularly economical gasket construction, which also requires very low closure forces, i.e. less than about 1 lb/inch (0.175 N/mm), is marketed by the Chomerics Division of Parker-Hannifin Corp., Woburn, Mass. under the tradenarne "Soft-Shield ® 5000 Series." Such construction consists of an electrically-conductive jacket or sheathing which is "cigarette" wrapped lengthwise over a polyurethane or other foam core. As is described further in U.S. Pat. No. 4,871,477, polyurethane foams generally are produced by the reaction of polyisocyanate and a hydroxyl-functional polyol in the presence of a blowing agent. The blowing agent effects the expansion of the polymer structure into a multiplicity of open or closed cells.

The jacket is provided as a highly conductive, i.e., about 1 Ω-sq., nickel-plated-silver, woven rip-stop nylon which is self-terminating when cut. Advantageously, the jacket may be bonded to the core in a continuous molding process wherein the foam is blown or expanded within the jacket as the jacket is wrapped around the expanding foam and the foam and jacket are passed through a die and into a traveling molding. Similar gasket constructions are shown in commonly-assigned U.S. Pat. No. 5,028,739 and in U.S. Pat. Nos. 4,857,668; 5,054,635; 5,105,056; and 5,202,536.

Many electronic devices, including PC's and communication equipment, must not only comply with certain FCC requirements, but also must meet be approved under certain Underwriter's Laboratories (UL) standards for flame retardancy. In this regard, if each of the individual components within an electronic device is UL approved, then the device itself does not require separate approval. Ensuring UL approval for each component therefore reduces the cost of compliance for the manufacturer, and ultimately may result in cheaper goods for the consumer. For EMI shielding gaskets, however, such gaskets must be made flame retardant, i.e., achieving a rating of V-0 under UL Std. No. 94, "Tests for Flammability of Plastic Materials for Parts in Devices and Appliances" (1991), without compromising the electrical conductivity necessary for meeting EMI shielding requirements.

In this regard, and particularly with respect to EMI shielding gaskets of the above-described fabric over foam

variety, it has long been recognized that foamed polymeric materials are flammable and, in certain circumstances, may present a fire hazard. Owing to their cellular structure, high organic content, and surface area, most foam materials are subject to relatively rapid decomposition upon exposure to fire or high temperatures.

One approach for imparting flame retardancy to fabric over foam gaskets has been to employ the sheathing as a flame resistant protective layer for the foam. Indeed, V-0 rating compliance purportedly has been achieved by sheathing the foam within an electrically-conductive Ni/Cu-plated fabric to which a thermoplastic sheet is hot nipped or otherwise fusion bonding to the underside thereof. Such fabrics, which may be further described in one or more of U.S. Pat. Nos. 4,489,126; 4,531,994; 4,608,104; and/or 4,621,013, have been marketed by Monsanto Co., St. Louis, under the tradename "Flectron® Ni/Cu Polyester Taffeta V0."

Other fabric over foam gaskets, as is detailed in U.S. Pat. No. 4,857,668, incorporate a supplemental layer or coating applied to the interior surface of the sheath. Such coating may be a flame-retardant urethane formulation which also promotes the adhesion of the sheath to the foam. The coating additionally may function to reduce bleeding of the foam through the fabric which otherwise could compromise the electrical conductivity of the sheath.

In view of the foregoing, it will be appreciated that further improvements in the design of flame retardant, fabric-over foam EMI shielding gaskets, as well as sheathing materials therefore, would be well-received by the electronics industry. Especially desired would be a flame retardant gasket construction which achieves a UL94 rating of V-0.

BROAD STATEMENT OF THE INVENTION

The present invention is directed to an electrically-conductive, flame retardant material for use in fabric-over-foam EMI shielding gaskets, and to a method of manufacturing the same. In having a layer of a flame retardant coating applied to one side of an electrically-conductive, generally porous fabric, the material of the invention affords UL94 V-0 protection when used as a jacketing in a fabric-over-foam gasket construction. Advantageously, as the flame retardant layer may be wet coated on the fabric without appreciable bleed through, a relatively thin, i.e., 2–4 mil (0.05–0.10 mm), coating layer may be provided on one fabric side without compromising the electrical surface conductivity of the other side. Such a thin coating layer, while being sufficient to provide UL94 V-0 protection, nonetheless maintains the drapability the fabric and thereby facilitates the construction UL94 V-0 compliant gaskets having complex profiles or narrow cross-sections down to about 1 mm.

In a preferred embodiment, the electrically-conductive, flame retardant EMI shielding material of the invention includes a nickel or silver-plated, woven nylon, polyester, or like fabric on one side of which is wet coated a layer of a flame retardant, acrylic latex emulsion or other fluent resin composition. In accordance with the precepts of the method of the invention, the viscosity and hydrodynamic pressure of the emulsion are controlled such that the coating does not penetrate or otherwise "bleed through" the uncoated side of the fabric. The surface conductivity of the opposite side of the fabric therefore is not compromised in EMI shielding applications.

The material of the invention may be employed as a jacket in fabric-over-foam EMI shielding gasket constructions, and is particularly adapted for use in the continuous molding process for such gaskets. As used within such process, the fabric may be wrapped around the foam as a jacket with coated side thereof being disposed as an interior surface adjacent the foam, and the uncoated side being disposed as an electrically-conductive exterior surface. Advantageously, the coating on the interior surface of the jacket blocks the pores of the fabric to retain the foam therein without penetrate or bleed through to the exterior surface. In being formed of a acrylic material, the coated interior surface of the jacket may function, moreover, depending upon the composition of the foam, as a compatibilizing or "tie" interlayer which promotes the bonding of the foam to the fabric.

The present invention, accordingly, comprises material and method possessing the construction, combination of elements, and arrangement of parts and steps which are exemplified in the detailed disclosure to follow. Advantages of the present invention include a flame retardant yet drapable EMI shielding fabric. Additional advantages include an economical, flame retardant EMI shielding fabric construction wherein a relatively thin layer of a flame retardant coating may be wet coated onto one side of an electrically-conductive, woven or other generally porous EMI shielding fabric without compromising the conductivity of the other side of the fabric. These and other advantages will be readily apparent to those skilled in the art based upon the disclosure contained herein.

BRIEF DESCRIPTION OF THE DRAWINGS

For a fuller understanding of the nature and objects of the invention, reference should be had to the following detailed description taken in connection with the accompanying drawings wherein:

FIG. **1** is a perspective view of one embodiment of an EMI shielding material according to the present invention which material includes a generally planar fabric member on one side of which is coated a layer of a flame retardant composition, the view being shown with portions being broken away to better reveal the structure of the material;

FIG. **2** is an enlarged cross-sectional view of the EMI shielding material of FIG. **1** taken through plane represented by line **2**—**2** of FIG. **1**;

FIG. **3** is a top view of the material of FIG. **1** which is magnified to reveal the structure of the fabric member thereof;

FIG. **4** is a perspective cross-sectional view of a length of a representative EMI shielding gasket construction according to the present invention including a jacket which is formed of the EMI shielding material of FIG. **1**;

FIG. **5** is an end view of the gasket of FIG. **4** which is magnified to reveal the structure thereof; and

FIG. **6** is a schematic, partially cross-sectional view of an illustrative gravity-fed, knife over roll coater as adapted for use in the manufacture of the EMI shielding material of FIG. **1**.

The drawings will be described further in connection with the following Detailed Description of the Invention.

DETAILED DESCRIPTION OF THE INVENTION

Certain terminology may be employed in the description to follow for convenience rather than for any limiting purpose. For example, the terms "upper" and "lower" designate directions in the drawings to which reference is made,

with the terms "inner" or "interior" and "outer" or "exterior" referring, respectively, to directions toward and away from the center of the referenced element, and the terms "radial" and "axial" referring, respectively, to directions perpendicular and parallel to the longitudinal central axis of the referenced element. Terminology of similar import other than the words specifically mentioned above likewise is to be considered as being used for purposes of convenience rather than in any limiting sense.

For the illustrative purposes of the discourse to follow, the electromagnetic interference (EMI) shielding material herein involved is described in connection with its use as a flame retardant, electrically-conductive jacket for a foam core, EMI shielding gasket as may be adapted to be received within an interface, such as between a door, panel, hatch, cover, or other parting line of an electromagnetic interference (EM) shielding structure. The EMI shielding structure may be the conductive housing of a computer, communications equipment, or other electronic device or equipment which generates EMI radiation or is susceptible to the effects thereof. The gasket may be bonded or fastened to, or press-fit into one of a pair of mating surfaces which define the interface within the housing, and functions between the mating surfaces to seal any interface gaps or other irregularities. That is, while under an applied pressure, the gasket resiliently conforms to any such irregularities both to establish a continuous conductive path across the interface, and to environmentally seal the interior of the housing against the ingress of dust, moisture, or other contaminates. It will be appreciated, however, that aspects of the present invention may find utility in other EMI shielding applications. Use within those such other applications therefore should be considered to be expressly within the scope of the present invention.

Referring then to the figures, wherein corresponding reference characters are used to designate corresponding elements throughout the several views, a flame retardant EMI shielding material according to the present invention is shown generally at **10** in FIG. **1** as generally adapted for use as a jacket within for a foam core gasket construction. For purposes of illustration, material sheet **10** is shown to be of indefinite dimensions which may be cut to size for the particular application envisioned. In basic construction, material **10** includes an upper, generally planar and porous fabric member, **12**, and a lower, flame retardant coating member, **14**.

Fabric member has at least an electrically-conductive first side, **16**, and a conductive or non-conductive second side, **18**, defining a thickness dimension, referenced at "t_1" in the cross-sectional view of FIG. **2**, which may vary from about 2–4 mils (0.05–0.10 mm). By "electrically-conductive," it is meant that the fabric may be rendered conductive, i.e., to a surface resistivity of about 0.1 Ω/sq. or less, by reason of its being constructed of electrically-conductive wire, monofilaments, yams or other fibers or, alternatively, by reason of a treatment such as a plating or sputtering being applied to non-conductive fibers to provide an electrically-conductive layer thereon. Preferred electrically-conductive fibers include Monel nickel-copper alloy, silver-plated copper, nickel-clad copper, Ferrex® tin-plated copper-clad steel, aluminum, tin-clad copper, phosphor bronze, carbon, graphite, and conductive polymers. Preferred non-conductive fibers include cotton, wool, silk, cellulose, polyester, polyanide, nylon, and polyimide monofilaments or yarns which are rendered electrically conductive with a metal plating of copper, nickel, silver, nickel-plated-silver, aluminum, tin, or an alloy thereof. As is known, the metal

plating may applied to individual fiber strands or to the surfaces of the fabric after weaving, knitting, or other fabrication.

While fabrics such as wire meshes, knits, and non-woven cloths and webs may find application, a preferred fabric construction for member **12** is a plain weave nylon or polyester cloth which is made electrically conductive with between about 20–40% by weight based on the total fabric weight, i.e., 0.01–0.10 g/in^2, of a silver, nickel-silver, or silver-nickel over copper plating. As may be seen in the magnified view of FIG. **1** referenced at **20** in FIG. **3**, such cloth is permeable in having a plain, generally square weave pattern with pores or openings, one of which is referenced at **22**, being defined between the fibers which are represented schematically at **24**. Fibers **24** may be yarns, monofilaments or, preferably, bundles of from about 10–20 filaments or threads, each having a diameter of between about 10–50 μm. For example, with fibers **24** each being a bundle of such threads with a thread count of between about 1000–3000 per inch and a weave count of between about 1000–1500 per inch, 1000–2000 openings per inch will be defined with a mean average pore size of between about 0.5–2 mils (12.5–50 μm).

Although a plain, square weave pattern such as a taffeta, tabby, or ripstop is considered preferred, other weaves such as satins, twills, and the like also should be considered within the scope of the invention herein involved. A particularly preferred cloth for fabric member **12** is a 4 mil (0.10 mm) thick, 1.8 oz/yd^2 weight, silver-plated, woven nylon which is marketed commercially under the designation "31EN RIPSTOP" by Swift Textile Metalizing Corp., Bloomfield, Conn. However, depending upon the needs of the specific shielding application, a fabric constructed of a combination or blend of conductive and nonconductive fibers alternatively may be employed. Examples of fabrics woven, braided, or warp knitted from electrically-conductive fibers, or from blends of conductive and non-conductive fibers, are described in Gladfelter, U.S. Pat. No. 4,684,762, and in Buonanno, U.S. Pat. No. 4,857,668.

Returning to FIGS. **1** and **2**, coating member **14** preferably is formed from a curable layer of a fluent, flame retardant resin or other composition which is wet coated onto the second side **18** of fabric member **12**. As is detailed hereinafter, the viscosity and hydrodynamic pressure of the resin composition are controlled in accordance with the precepts of the present invention to delimit the penetration of the resin layer to a depth, referenced at "d" in FIG. **2**, which is less than the thickness dimension t_1 of the fabric member **12**. In this regard, when the layer is cured to form the flame retardant surface coating member **14** on the second side **18** of fabric member **12**, the first side **16** thereof remains electrically-conductive. In a preferred construction, the layer is coated to a wet thickness of about 10 mils (0.25 mm), and then cured to a dried coating or film thickness, referenced at t_2 in FIG. **2**, of between about 2–4 mils (0.05–0.10 mm) at a depth d of about 1–2 mils (0.025–0.05 mm). Ultimately, a total material thickness, referenced at "T," of between about 6–7 mils (0.15–0.20 mm) and a dried weight pickup of between about 100–150 g/yd^2 are observed. By "cured" it is meant that the resin is polymerized, cross-linked, further cross-linked or polymerized, vulcanized, hardened, dried, volatilized, or otherwise chemically or physically changed from a liquid or other fluent form into a solid polymeric or elastomeric phase.

The flame retardant composition preferably is formulated as an aqueous emulsion of an acrylic latex emulsion which is adjusted to a total solids of about 60% and a Brookfield

viscosity (#5 spindle, 4 speed) of between about 40,000–60,000 cps, at a density of about 10 lbs per gallon (1.8 g/cm^3). Flame retardancy may be imparted by loading the emulsion with between about 30–50% by weight of one or more conventional flame retardant additives such as aluminum hydrate, antimony trioxide, phosphate esters, or halogenated compounds such as polybrominated diphenyl oxides. A preferred formulation is a mixture of about 25% by weight, based on the total weight of the emulsion, of decambromodiphenyl oxide and about 15% by weight of one or more antimony compounds. In operation, should the acrylic carrier phase be ignited, the decomposition of the halogenated and metal oxide compounds function to chemically deprive the flame of sufficient oxygen to support combustion. The decomposition of the acrylic phase additionally may lead to the development of a protective, i.e., thermally-insulative or refractory, outer char layer.

A preferred flame retardant, acrylic latex emulsion is marketed commercially by Heveatex Corp., Fall River, Mass., under the designation "4129FR." The viscosity of the emulsion may be adjusted to between about 40,000–60,000 cps using an aqueous acryloid get or other acrylic thickener. In this regard, the increased viscosity of the emulsion contributes to delimiting the penetration of the coating layer into the fabric member. However, as this relatively high viscosity may lead to undesirable porosity in the dried film, the emulsion additionally may be modified to reduce air entrapment and bubble formation in the coating layer with up to about 1% by weight of one or more commercial surfactants such as "Bubble Breaker" by Witco Chemical Corp. (Chicago, Ill.) and "Foam Master Antifoam" by Diamond Shamrock, Inc. (San Antonio, Tex.).

As aforementioned, EMI shielding material **10** of the present invention is particularly adapted for use as a flame retardant, electrically-conductive jacket which is provided over a foam core in an EMI shielding gasket construction such as gasket **50** of FIG. **4**. In a representative embodiment, gasket **50** includes an elongate, resilient foam core member, **52**, which may be of an indefinite length. Core member **52** has an outer circumferential surface, **54**, defining the cross-sectional profile of gasket **50** which, for illustrative purposes, is of a generally polygonal, i.e., square or rectangular geometry. Other plane profiles, such as circular, semi-circular, or elliptical, or complex profiles may be substituted, however, depending upon the geometry of the interface to be sealed. Core member **12** may be of any radial or diametric extent, but for most applications will have a diametric extent or width of from about 0.25 inch (0.64 cm) to 1 inch (2.54 cm).

For affording gap-filling capabilities, it is preferred that core member **52** is provided to be complaint over a wide range of temperatures, and to exhibit good compression-relaxation hysteresis even after repeated cyclings or long compressive dwells. Core member **52** therefore may be formed of a foamed elastomeric thermoplastic such as a polyethylene, polypropylene, polypropylene-EPDM blend, butadiene, styrene-butadiene, nitrile, chlorosulfonate, or a foamed neoprene, urethane, or silicone. Preferred materials of construction include open or closed cell urethanes or blends such as a polyolefin resin/monoolefin copolymer blend, or a neoprene, silicone, or nitrile sponge rubber.

Core member **52** may be provided as an extruded or molded foam profile over which shielding material **10** is wrapped as a sheathed, with the edges of sheathed being overlapped as at **56**. In a preferred construction, shielding material **10** is bonded to the core member **52** in a continuous molding process wherein the foam is blown or expanded within the shielding material. As may be seen best with reference to the magnified view of FIG. **4** referenced at **60** in FIG. **5**, in such construction coating member **14** is disposed adjacent core member **52** as an interior surface, **62**, of shielding member **10**, with the uncoated side **16** of fabric member **12** being oppositely disposed as an electrically-conductive exterior surface, **64**, of the gasket **50**. It will be appreciated that the coated interior surface **62** blocks the pores **22** (FIG. **3**) of the fabric member **12** of the fabric to retain the blown foam therein without penetrate or bleed through to the exterior gasket surface **64**. Depending upon the respective compositions of the foam and coating, the interior surface **62** may function, moreover, as a compatibilizing or "tie" interlayer which promotes the bonding of the foam to the fabric. Gasket construction **50** advantageously provides a structure that may be used in very low closure force, i.e. less than about 1 lb/inch (0.175 N/mm), applications.

Referring again to FIG. **4**, an adhesive layer, **70**, may be applied along the lengthwise extent of gasket **50** to the underside of exterior surface **64** for the attachment of the gasket to a substrate. Such layer **70** preferably is formulated to be of a pressure sensitive adhesive (PSA) variety. As is described in U.S. Pat. No. 4,988,550, suitable PSA's for EMI shielding applications include formulations based on silicones, neoprene, styrene butadiene copolymers, acrylics, acrylates, polyvinyl ethers, polyvinyl acetate copolymers, polyisobutylenes, and mixtures, blends, and copolymers thereof. Acrylic-based formulations, however, generally are considered to be preferred for the EMI applications of the type herein involved. Although PSA's are preferred for adhesive layer **70**, other adhesives such as epoxies and urethanes may be substituted and, accordingly, are to be considered within the scope of the present invention. Heat-fusible adhesives such a hot-melts and thermoplastic films additionally may find applicability.

Inasmuch as the bulk conductivity of gasket **50** is determined substantially through its surface contact with the substrate, an electrically-conductive PSA may be preferred to ensure optimal EMI shielding performance. Such adhesives conventionally are formulated as containing about 1–25% by weight of a conductive filler to yield a volume resistivity of from about 0.01–0.001 Ω-cm. The filler may be incorporated in the form of particles, fibers, flakes, microspheres, or microballoons, and may range in size of from about 1–100 microns. Typically filler materials include inherently conductive material such as metals, carbon, and graphite, or nonconductive materials such as plastic or glass having a plating of a conductive material such as a noble metal or the like. In this regard, the means by which the adhesive is rendered electrically conductive is not considered to be a critical aspect of the present invention, such that any means achieving the desired conductivity and adhesion are to be considered suitable.

For protecting the outer portion of adhesive layer **70** which is exposed on the exterior surface of the gasket, a release sheets, shown at **72**, may be provided as removably attached to the exposed adhesive. As is common in the adhesive art, release sheet **72** may be provided as strip of a waxed, siliconized, or other coated paper or plastic sheet or the like having a relatively low surface energy so as to be removable without appreciable lifting of the adhesive from the exterior surface **64**.

In the production of commercial quantities of the EMI shielding material **10** of the present invention, the viscosity adjusted and otherwise modified acrylic latex emulsion or other resin composition may be coated and cured on one side

the fabric member **12** by a direct wet process such as knife over roll or slot die. With whatever process is employed, the hydrodynamic pressure of the resin composition is controlled in accordance with the precepts of the present invention to delimit the penetration of the resin layer to a depth which is less than the thickness dimension of the fabric member. For example, and with reference to FIG. **6** wherein the head of a representative gravity-fed knife over roll coater is shown somewhat schematically at **100**, porous, i.e., permeable, fabric member **12** is conveyed from a feed roll or the like (not shown) over a nip roller, **102**, which rotates in the direction referenced by arrow **104**. With the first side **16** of fabric member **12** supported on roller **102**, the fabric second side **18** is passed beneath the opening, referenced at **106**, of a coating trough, **108**. Trough **108** is defined by a front plate, **10**, a back plate, **112**, and a pair of side plates (not shown).

The emulsion or other fluent resin composition, referenced at **114**, is pumped or otherwise transported into trough **108** which is filled to a fluid level, referenced at h. For a given fluid density, this level h is controlled such that the hydrodynamic pressure at the fabric-liquid interface is maintained within preset limits. For example, with a fluid density of about 10 pounds per gallon (1.8 g/cm^3), and a fabric having a porosity of about 1000–2000 openings per inch with a mean average pore size of between about 0.5–2 mils (12.5–50 μm), the fluid level H is controlled at about 4 inches (10 cm) to yield a hydrodynamic pressure of about 0.05 psi (0.35 kPa) at the fabric-liquid interface. For other coating processes, the hydrodynamic fluid pressure may be controlled, for example, by a pumping pressure or the like.

In the illustrative knife-over-roll coating process, the lower edge, **120**, of front plate **110** defines a knife surface which is shimmed or otherwise spaced-apart a predetermined distance from the second side **18** of fabric member **12**. Such spacing provides a clearance or gap, referenced at "g," of typically about 10 mils (0.25 mm), but which is adjustable to regulate the thickness of the liquid coating layer, **122**, being applied to the fabric member. From roller **104**, the coated fabric member **12** may be conveyed via a take-up roller arrangement (not shown) through a in-line oven or the like to dry or flash the water or other diluent in the liquid coating layer **122**, or to otherwise cure the liquid coating layer **122** in developing an adherent, tack-free, film or other layer of coating member **14** (FIG. **1**) on the single side **18** of fabric member **12**.

The Example to follow, wherein all percentages and proportions are by weight unless otherwise expressly indicated, is illustrative of the practicing of the invention herein involved, but should not be construed in any limiting sense.

EXAMPLE

Representative EMI shielding materials according to the present invention were constructed for characterization. In this regard, a master batch of a flame retardant coating composition was compounded using an acrylic latex emulsion (Heveatex "4129FR"). The viscosity of the emulsion was adjusted to a Brookfield viscosity (#4 spindle, 40 speed) of about 60,000 cps with about 5wt % of an acryloid thickener (Acrysol™GS, Monsanto Colo., St. Louis, Mo.). The modified emulsion had a total solids content of about 60% by weight, a density of about 10 pounds per gallon (1.8 g/lcm^3), and a pH of between about 7.5 and 9.5.

The emulsion was applied using a knife over roll coater (JETZONE Model 7319, Wolverine Corp., Merrimac,

Mass.) to one side of a silver-plated nylon fabric (Swift "31EN RIPSTOP") having a thickness of about 4 mils (0.1 mm). With the fluid level in the coating trough of the coater maintained at about 4 inch (10 cm), the emulsion was delivered to the surface of the cloth at a hydrodynamic pressure of about 0.05 psi (0.35 kPa). The coating knife was shimmed to a 10 mil (0.25 mm) gap above the fabric to yield a wet coating draw down thickness of about 10 mils. Following an oven curing at 100–125° C. for 5 minutes, a dried coating or film thickness of about 2.5 mils (0.635 mm) was obtained with a weight pickup of about 130–145 g/yd^2 and a total material thickness of between about 6–7 mils (0.15–0.18 mm). An inspection of the coated fabric cloth revealed a coating penetration depth of about 1–2 mils (0.02–0.05 mm) providing acceptable mechanical retention and/or adhesion of the coating onto the fabric surface. The opposite side of the fabric, however, was observed to be substantially coating free, and to retain a surface resistivity of about 0.1 Ω/sq for unaffected EMI shielding effectiveness.

Fabric samples similarly coated in the manner described were subjected to an in-house vertical flame test. No burning was observed at dried film thickness of 2, 3, or 4 mils (0.05, 0.08, 0.10 mm). Accordingly, a reasonable operating window of film thickness was suggested for production runs.

Samples also were provided, as jacketed over a polyurethane foam core in an EMI shielding gasket construction, for flame testing by Underwriters Laboratories, Inc., Melville, N.Y. A flame class rating of V-0 under UL94 was assigned at a minimum thickness of 1.0 mm. The gasket construction therefore was found to be compliant with the applicable UL requirements, and was approved to bear the "UL" certification mark.

The foregoing results confirm that the EMI shielding material of the present invention affords UL94 V-0 protection when used as a jacketing in a fabric-over-foam gasket construction. Unexpectedly, it was found that a relatively porous or permeable fabric may be wet coated on one side with a relatively thin, i.e., 2–4 mil (0.05–0.10 mm), coating layer of a flame retardant composition without compromising the electrical surface conductivity of the other side. Such a thin coating layer, while being sufficient to provide UL94 V-0 protection in a conventional fabric-over-foam gasket construction, nonetheless maintains the drapability the fabric and thereby facilitates the fabrication of UL94 V-0 compliant gaskets having complex profiles or narrow cross-sections down to about 1 mm.

As it is anticipated that certain changes may be made in the present invention without departing from the precepts herein involved, it is intended that all matter contained in the foregoing description shall be interpreted as illustrative and not in a limiting sense. All references cited herein are expressly incorporated by reference.

What is claimed is:

1. A flame retardant, electromagnetic interference (EMI) shielding gasket comprising:

a resilient core member extending lengthwise along a central longitudinal axis and having an outer surface extending circumferentially about said longitudinal axis, said core member being formed of a foamed elastomeric material;

an electrically-conductive fabric member surrounding the outer surface of said core member, said fabric member having an interior surface disposed facing the outer surface of said core member and an oppositely-facing, exterior surface, at least the exterior surface being

electrically-conductive and the exterior surface defining with the interior surface a thickness dimension of the fabric member therebetween; and

a flame retardant layer coating at least a portion of the interior surface of said fabric member, said flame retardant layer comprising at least about 50% by dry weight of one or more flame retardant additives and penetrating into said fabric member to a depth which is less than the thickness dimension of said fabric member such that the exterior surface of said fabric member remains electrically-conductive.

2. The gasket of claim **1** wherein said flame retardant layer has a thickness of between about 2–4 mils (0.05–0.10 mm).

3. The gasket of claim **1** wherein said flame retardant layer is formed as a cured film of a flame retardant acrylic latex emulsion.

4. The gasket of claim **1** wherein said fabric member is a metal-plated cloth.

5. The gasket of claim **4** wherein said cloth comprises fibers selected from the group consisting of cotton, wool, silk, cellulose, polyester, polyamide, nylon, and combinations thereof, and said metal is selected from the group consisting of copper, nickel, silver, nickel-plated-silver, aluminum, tin, and combinations thereof.

6. The gasket of claim **1** wherein said foamed elastomeric material is selected from the group consisting of polyethylenes, polypropylenes, polypropylene-EPDM blends, butadienes, styrene-butadienes, nitriles, chlorosulfonates, neoprenes, urethanes, silicones, and polyolefin resin/monoolefin copolymer blends, and combinations thereof.

7. The gasket of claim **1** wherein said fabric member has a thickness of between about 2–4 mils (0.05–0.10 mm).

8. The gasket of claim **1** wherein said flame retardant layer is effective to afford the gasket a flame class rating of V-0 under Underwriter's Laboratories (UL) Standard No. 94.

9. The gasket of claim **1** wherein said one or more flame retardant additives are selected from the group consisting of aluminum hydrate, antimony trioxide, phosphate esters, and halogenated compounds.

10. The gasket of claim **1** wherein said flame retardant layer comprises between about 50–83% by dry weight of one or said one or more flame retardant additives.

* * * * *

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FISH & RICHARDSON P.C.

Citigroup Center
153 East 53rd Street,
52nd Floor
New York, New York
10022-4611

Telephone
212 765-5070

Facsimile
212 258-2291

Web Site
www.fr.com

Frederick P. Fish
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May 16, 2008

VIA E-MAIL AND FEDERAL EXPRESS

Mr. Steven A. Nash
Connolly Bove Lodge & Hutz LLP
The Nemours Building
1007 North Orange Street
Wilmington, DE 19899

**Re: Parker-Hannifin Corporation, etc. v. Zippertubing (Japan) Ltd.
Civil Action No. 06-751-MPT (D.Del.)
Exchange of Preliminary Claim Constructions**

Dear Steve:

Pursuant to the agreement between the parties to exchange preliminary claim constructions, Zippertubing hereby adopts the preliminary claim constructions offered by Seiren.

Zippertubing reserves the right to fine tune its preliminary claim constructions. Zippertubing also reserves the right to argue that any claim terms are indefinite, including but not limited to (1) "by weight" in claim 8 of the '348 patent and claim 1 of the '536 patent, because dry or wet weight is not specified, and (b) "core member [which] is not V-0 rated under Underwriter's [*sic*] Laboratories (UL) Standard No. 94" in claims 1, 16 and 17 of the '348 patent, because Underwriters Laboratories Inc. does not offer such ratings for foam.

Very truly yours,

David Loretto

cc: Scott Daniels, Esq. (by e-mail only)
Jim Lennon, Esq. (by e-mail only)

EXHIBIT
F

ROGERS
CORPORATION

High Performance Foams Division
171 West St. Charles Road
Carol Stream, IL 60188
Tel: 630.784.6200 / Fax: 630.784.6201
www.rogerscorporation.com

BISCO® Silicones

Typical Product Properties

BISCO® HT-840 – EXTRA FIRM CELLULAR SILICONE

HT-840 is an extra-firm grade silicone foam that offers improved durability and sealing. It is used to seal and protect various outdoor communication, lighting, and electronic enclosures from small dust particles, wind driven rain, and fire. It offers a higher tear and tensile strength than our lighter grade foams. BISCO® Silicones are available in various thicknesses and manufactured in roll form to allow fabricators to easily convert the material to the proper dimensions.

Features and Benefits

- Excellent memory and low stress relaxation reduces maintenance costs associated with gasket failures due to compression set and softening.
- Resistance to ultraviolet light, ozone, extreme temperatures, and flame enables consistent performance in all environments.
- Compact cell structure provides improved sealing performance.
- Available through distribution sites throughout North America, Europe, and Asia.

Applications

- Environmental seals to protect against penetration of dust, moisture, air, or light within outdoor enclosures such as lighting fixtures, HVAC units, and electronic cabinets
- Enclosures requiring a more durable, high closure force gasket.
- Press pads requiring greater conformability and even pressure distribution at high temperatures

Installation

- Available with a pressure-sensitive adhesive on one or two sides to allow easy application to a variety of surfaces.

BISCO® HT-840

Property	Test Method	Typical Value
PHYSICAL		
Color		Gray
Thickness, inches (mm) **Tolerance**		1/16 to 1/4 (1.6 – 6.4) See Reverse
Standard Width, inches (mm)		28 (449)
Density, lb./ft³ (kg/m³)	ASTM D 1056	27 (432)
Compression Force Deflection, psi (kPa)	Force measured @ 25% Deflection ASTM D 1056	22 (151.7)
Compression Set, % max.	ASTM D 1056 Test D @ 158°F (70°C)	< 1
	ASTM D 1056 Test D @ 212°F (100°C)	< 5
Tensile Strength, psi (kPa)	ASTM D 412	60 (414)
Elongation, %	ASTM D 412	60
FLAMMABILITY & OUTGASSING		
Flame Resistance	UL 94	Listed V-0 and HF-1
Flame Spread Index (I_s)	ASTM E 162	< 25
Smoke Density (D_s)	ASTM E 662 Tested @ 4.0 minutes	< 50
	Tested @ 1.5 minutes	< 20
Toxic Gas Emissions Rating	SMP-800C	Pass

Please see reverse for additional data.

BISCO® HT-840 – EXTRA FIRM CELLULAR SILICONE (continued)

PROPERTY	TEST METHOD	VALUE
ENVIRONMENTAL PROPERTIES		
Water Absorption	Internal: 24 hrs @ room temp.	0.20 %
UV Resistance	SAE J - 1960	No Degradation
Ozone Effect Rating	ASTM D 1171	0 (No Cracks)
Corrosion Resistance	AMS - 3568	Pass
ELECTRICAL & THERMAL PROPERTIES		
Dielectric Constant	ASTM D 150	1.58
Dielectric Strength	ASTM D 149, Volts/mil	95
Dry Arc Resistance	ASTM D 495, Seconds	98
Volume Resistivity, Ohm - cm	ASTM D 257	10^{14}
Thermal Conductivity, BTU in/hr/ft²/°F (w/m °K)	ASTM C 518	0.84 (0.12)
TEMPERATURE RESISTANCE		
Low Temperature Flex at -67°F (-55°C)	ASTM D 1056	Pass
Recommended Use Temperature, °F (°C)	SAE J-2236	-67 to 392 (-55 to 200)
Recommended Intermittent High Temperature Use, °F (°C)	Internal	482 (250)

Standard Thickness Tolerance

Standard Thickness			Tolerance (Inches)
Inches		mm	
1/16	0.062	1.57	± 0.020
3/32	0.094	2.39	± 0.020
1/8	0.125	3.18	± 0.025
3/16	0.188	4.76	± 0.025
1/4	0.250	6.35	± 0.040

Width Tolerance (Cellular)

Nominal Width (Inches)	Tolerance (w/o PSA)	Tolerance (with PSA)
0 < T ≤ 3	± 0.063	± 0.031
3 < T ≤ 8	± 0.094	± 0.031
8 < T ≤ 12	± 0.125	± 0.031
12 < T ≤ 18	± 0.188	± 0.031
18 < T ≤ 26	± 0.219	± 0.063
26 < T ≤ 36	± 0.250	± 0.063

Notes:
1. All metric conversions are approximate.
2. Additional technical information is available.
3. Typical values are a representation of an average value for the population of the property. For specification values contact Rogers Corporation.

7147-1007-PDF, **Publication #180-072**

EXHIBIT
G

WEBSTER'S NEW TWENTIETH CENTURY DICTIONARY OF THE ENGLISH LANGUAGE

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1979

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obtained by the destructive distillation of bituminous coal: many synthetic compounds have been developed from it, including dyes, medicines, explosives, and perfumes.

cōal′tit, *n.* see *coalmouse.*

cōal′-whip″pẽr, *n.* in England, one who or that which raises coal out of the hold of a ship; a coal heaver.

cōal wŏrks, a coal mine; a colliery; a place where coal is dug.

cōal′y, *a.*; *comp.* coalier; *superl.* coaliest. like coal; containing coal; of the nature of coal; of the color of coal.

cōam′ing, *n.* [from ME. *comb*; AS. *camb*, a comb.]

1. a raised border around a roof opening, well, etc.

2. one of the raised borders or edges of the hatches of a ship, made to keep out water.

cō·an·nex′, *v.t.* to annex with something else. [Rare.]

cō·apt′, *v.t.* to fit together: also written *coaptate.*

cō·ap·tā′tion, *n.* [LL. *coaptatio*, from *coaptare*, to fit together.] the adaptation or adjustment of parts to each other, as of the ends of a broken bone.

cō·ärb′, *n.* [Ir. *comharba*, a successor, abbot.] the abbot of a monastery: also called *comarb.*

cō·ärct′, *v.t.* to crowd; to restrain: also spelled *coarctate.* [Obs.]

cō·ärc′tāte, *a.* [L. *coarctatus*, pp. of *coarctare*, to compress; *co-*, together, and *arctare*, to press.] in biology, (a) closely connected; (b) having the thorax and abdomen separated only by a constriction.

coarctate pupa; a pupa enclosed by the stiffened larval skin.

cō·ärc·tā′tion, *n.* 1. confinement; restraint to a narrow space; restraint of liberty. [Obs.]

2. pressure; contraction; specifically, in medicine, the contraction or lessening of the diameter of a canal, as the intestinal canal or the urethra.

cōarse, *a.*; *comp.* coarser; *superl.* coarsest. [formerly written *course, cowrse*, and believed to be the same word as *course*. A thing *of course*, or *in course*, is what is natural, ordinary, common, and hence probably the development of the meaning.]

1. lacking in fineness of texture or structure, or in elegance of form; composed of large parts or particles; thick and rough in texture; as, *coarse* thread; *coarse* hair; *coarse* sand; *coarse* glass; *coarse* features.

2. rude; rough; unrefined; uncivil; unpolished; as, *coarse* manners.

3. gross; indelicate; as, he indulged in *coarse* language.

4. common; of inferior or poor quality.

Syn.—bluff, brutish, large, thick, blunt, uncouth, immodest, vulgar.

cōarse′-grāined′, *a.* 1. consisting of large particles or constituent elements; having a coarse or rough texture; as, *coarse-grained* granite or wood.

2. lacking in refinement or delicacy; vulgar; as, a *coarse-grained* nature.

cōarse′ly, *adv.* in a coarse manner.

cōars′en, *v.t.* and *v.i.* to make or become coarse.

cōarse′ness, *n.* the state or quality of being coarse.

cō·är·tic·ū·lā′tion, *n.* in anatomy, the fitting together of bones to form a joint. [Obs.]

cō″as·sess′ŏr, *n.* a joint assessor.

cōast, *n.* [ME. *coste, coost*, coast; OFr. *coste*, a rib, hill, shore, coast; L. *costa*, a rib, a side.]

1. the exterior line, limit, or border of a country. [Obs.]

2. the edge or margin of the land next to the sea; the seashore; also, the country near the seashore; as, populous towns along the *coast.*

3. the side of an object. [Obs.]

4. a slide downhill, as on a sled; a ride down an incline without using propelling power, as on a bicycle.

5. the incline down which a slide is taken.

the Coast; in the United States, the Pacific coast.

the coast is clear; there is no apparent danger or hindrance.

cōast, *v.i.*; coasted, *pt., pp.*; coasting, *ppr.*

1. to sail near a coast; to sail along or near the shore, or in sight of land.

The ancients *coasted* only in their navigation. —Arbuthnot.

2. to make short voyages from port to port.

3. to go down an incline on a sled.

4. to continue in motion on momentum or by the force of gravity after propelling power has stopped.

5. to behave aimlessly; not make any serious effort.

6. to approach. [Obs.]

cōast, *v.t.* 1. to sail along or near to; as, to *coast* the American shore.

2. to draw near; to approach; to follow. [Obs.]

cōast′ăl, *a.* of, at, near, or along a coast.

cōast′ăl plāin, level land extending along a coast.

cōast är·til′lẽr·y, that branch of the armed forces assigned to protect the harbors and coast lines of the nation, and generally armed with artillery and antiaircraft guns of the largest caliber: distinguished from *field artillery.*

cōast′ẽr, *n.* 1. a person or thing that coasts.

2. a vessel employed in sailing or in trading from port to port along a coast.

3. formerly, a small tray on wheels for passing a decanter around a table.

4. a small round tray placed under a glass or bottle to protect a table or other surface.

5. a sled, etc. suitable for coasting.

6. an amusement railway that runs on a specially constructed framework with sharp dips and curves; a roller coaster.

cōast′ẽr brāke, a brake in the hub of the rear wheel of a bicycle, operated by reversing the pressure on the pedals: it also releases the wheel from the driving mechanism to permit free coasting.

cōast guärd, 1. a group of men employed by a government to defend its coasts, prevent smuggling, aid vessels in distress, maintain lighthouses, etc.

2. [C— G—] such a group in the United States: normally under the control of the Treasury Department, in time of war it is placed under the control of the navy.

3. a member of a coast guard.

cōast′ing, *a.* sailing along or near a coast; as, a *coasting* schooner.

coasting trade; trade which is carried on along a coast from port to port, especially within one country.

cōast′ing, *n.* the act of one who or of that which coasts.

cōast land, *n.* land along a coast.

cōast līne, the contour or outline of a coast.

cōast rat, a small mammal, *Bathyergus maritimus*, of South Africa. It is about the size of a rabbit, and is also called *mole rat* or *sand mole.* Its burrows are exceedingly large.

cōast′wāit″ẽr, *n.* in England, a customs officer who oversees the loading and landing of goods in the coasting trade: also called *landwaiter.*

cōast′wărd, *a.* and *adv.* toward the coast.

cōast′wărds, *adv.* coastward.

cōast′wāys, *adv.* coastwise.

cōast′wīse, *adv.* and *a.* by way of or along the coast.

cōat, *n.* [ME. *cote, coote*; OFr. *cote*, a coat; LL. *cota, cotta*, a tunic.]

1. a sleeved outer garment opening down the front and extending usually just below the hips, worn as part of a suit or as a jacket.

2. a similar garment of varying length, worn out of doors over one's usual clothing.

3. a natural outer covering of an animal, as of skin, fur, wool, etc.

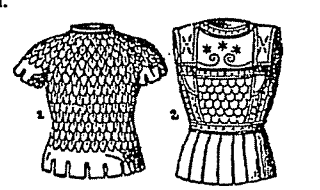
4. the outer covering of a plant or of an animal structure or tissue.

5. a layer of some substance, as paint, over a surface.

6. a petticoat or skirt. [Dial.]

7. customary garb showing one's position, class, etc. [Obs.]

coat of mail; a piece of armor, in the shape of a coat, made of joined metal links, or chain mail.



COATS OF MAIL—1. Roman 2. Greek

cōat, *v.t.*; coated, *pt., pp.*; coating, *ppr.* 1. to cover or spread over with a layer of any substance; as, to *coat* a ceiling with paint.

2. to provide or cover with a coat.

cōat är′mŏr, 1. an outer coat worn over the armor, bearing heraldic devices. [Obs.]

2. a coat of arms; an escutcheon with crest, motto, etc.

cōat cärd, the king, queen, or jack in a deck of playing cards; a face card: usually called *court card.*

cōat′ed pā′pẽr, a paper whose surface has been treated so that it will take half-tone impressions or color printing.

cōat·ee′, *n.* a short, close-fitting coat, usually with a short skirt or tails.

cō·ä′ti, *n.* [native name.] a small, flesh-eating animal of Central and South America, resembling the raccoon, but with a longer body and a long flexible snout.

cō·ä′ti-mŏn′di, cō·ä′ti-mun′di, *n.* [Tupi; *coati*, and *mondi*, solitary.] a coati.

cōat′ing, *n.* 1. the act of covering; also, any substance spread over for cover or protection; as, a *coating* of enamel.

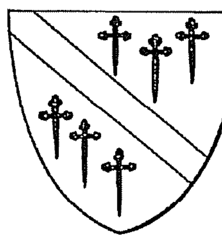
2. cloth for making coats; as, an assortment of *coatings.*

cōat link, studs or buttons joined by a link, or a loop and button, for fastening a coat.

cōat of ärms, [after Fr. *cotte d'armes*, light garment worn over armor, and generally blazoned with the heraldic arms of the wearer.]

1. a shield marked with the insignia or designs (heraldic bearings) of a person, family, institution, etc.

2. a representation of such a shield.



COAT OF ARMS

cōat′tāil, *n.* 1. the back part of a coat below the waist.

2. one half of the skirt of a coat that is divided in the back.

3. either of the two long, tapering skirts on the back of a man's dress coat.

cō·au′thŏr, *n.* a joint author; collaborator.

cōax, *v.t.*; coaxed (kōxt), *pt., pp.*; coaxing, *ppr.* [from *coax*, a fool: origin obscure.]

1. to induce or try to induce to do something; to persuade by soothing words, flattery, etc.; to wheedle.

2. to get by coaxing.

Syn.—wheedle, cajole, flatter, entice.

cōax, *v.i.* to use persuasion, flattery, etc.

cō·ax′ăl, *a.* coaxial.

cōax′ẽr, *n.* a wheedler; someone who coaxes.

cō·ax′i·ăl, *a.* 1. having an axis, or axes, in common.

2. designating a compound loudspeaker consisting of a smaller unit mounted within and connected with a larger one on a common axis: the smaller unit reproduces the higher frequencies, beyond the range of the larger.

cō·ax′i·ăl cā′ble, a cable made up of an insulated conductor tube through which a number of conducting wires are passed, and by means of which many telephone, television, and telegraph impulses can be sent simultaneously.

cōax′ing, *n.* the act of wheedling or leading on by kind treatment.

cōax′ing·ly, *adv.* by coaxing; in a coaxing manner.

cob, *n.* [origin obscure; the primary idea doubtless being that of head; compare G. *kopf*; AS. *cop, copp*, head.]

1. the top or head. [Obs.]

2. the tough core on which the kernels of corn grow; a corncob; hence, a corncob pipe.

3. the black-backed sea gull; the sea cob: also spelled *cobb.*

4. a ball or pellet for feeding fowls.

5. a spider. [Rare.]

6. a short, thickset horse.

7. unburned clay mixed with straw, as in cobwalls, which are used in constructing cottages in some parts of England.

8. a large stone, lump of coal, or round mass of any material.

EXHIBIT H

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Appl. No.	:	10/753,016
Applicant	:	Bunyan, *et al.*
Filed	:	January 7, 2004
Title	:	Flame Retardant EMI Shielding Gasket
TC/A.U.	:	
Examiner	:	
Docket No.	:	2802-257-023

Honorable Commissioner For Patents
Alexandria, VA 22313-1450

PRELIMINARY AMENDMENT UNDER 37 C.F.R. § 1.115

Pursuant to 37 C.F.R. § 1.115, please amend the above-identified application as follows:

Amendments to the Claims are reflected in the listing of the claims which begins on page 2 of this paper.

Remarks begin on page 4 of this paper.

This listing of claims will replace all prior versions, and listing, of claims in the application.

Listing of Claims:

Claim 1 (currently amended): A flame retardant, electromagnetic interference (EMI) shielding gasket comprising:

a resilient core member extending lengthwise along a central longitudinal axis and having an outer surface extending circumferentially about said longitudinal axis, said core member being formed of a foamed elastomeric material;

an electrically-conductive fabric member surrounding the outer surface of said core member, said fabric member having an interior surface disposed facing the outer surface of said core member and an oppositely-facing, exterior surface, at least the exterior surface being electrically-conductive and the exterior surface defining with the interior surface a thickness dimension of the fabric member therebetween; and

a flame retardant layer coating at least a portion of the interior surface of said fabric member, said flame retardant layer ~~being effective to afford said gasket a flame class rating of V-0 under Underwriter's Laboratories (UL) Standard No. 94~~ comprising at least about 50% by dry weight of one or more flame retardant additives and penetrating into said fabric member to a depth which is less than the thickness dimension of said fabric member such that the exterior surface of said fabric member remains electrically-conductive.

Claim 2 (original): The gasket of claim 1 wherein said flame retardant layer has a thickness of between about 2-4 mils (0.05-0.10 mm).

Claim 3 (currently amended): The gasket of claim 1 wherein said flame retardant layer [of] is formed as a cured film of a flame retardant acrylic latex emulsion.

Claim 4 (original): The gasket of claim 1 wherein said fabric member is a metal-plated cloth.

Claim 5 (original): The gasket of claim 4 wherein said cloth comprises fibers selected from the group consisting of cotton, wool, silk, cellulose, polyester, polyamide, nylon, and combinations thereof, and said metal is selected from the group consisting of copper, nickel, silver, nickel-plated-silver, aluminum, tin, and combinations thereof.

Claim 6 (original): The gasket of claim 1 wherein said foamed elastomeric material is selected from the group consisting of polyethylenes, polypropylenes, polypropylene-EPDM blends, butadienes, styrene-butadienes, nitriles, chlorosulfonates, neoprenes, urethanes, silicones, and polyolefin resin/monoolefin copolymer blends, and combinations thereof.

Claim 7 (original): The gasket of claim 1 wherein said fabric member has a thickness of between about 2-4 mils (0.05-0.10 mm).

Claim 8 (new): The gasket of claim 1 wherein said flame retardant layer is effective to afford the gasket a flame class rating of V-0 under Underwriter's Laboratories (UL) Standard No. 94.

Claim 9 (new): The gasket of claim 1 wherein said one or more flame retardant additives are selected from the group consisting of aluminum hydrate, antimony trioxide, phosphate esters, and halogenated compounds.

Claim 10 (new): The gasket of claim 1 wherein said flame retardant layer comprises between about 50-83% by dry weight of one or said one or more flame retardant additives.

REMARKS

Consideration of the above-identified application as amended respectfully is solicited on behalf of the Applicants. With the instant response, 2 claims have been amended and 3 claims have been newly added.

A terminal disclaimer is filed herewith in compliance with 37 C.F.R. § 1.321(b) is filed herewith. The certification required under 37 C.F.R. § 3.73 accompanies the disclaimer.

Claim 1 has been amended in the interest of clarity to recite that "at least the exterior surface [of the fabric member is] electrically-conductive and the exterior surface defin[es] with the interior surface a thickness dimension of the fabric member therebetween," and further that the flame retardant layer "penetrat[es] into said fabric member to a depth which is less than the thickness dimension of said fabric member such that the exterior surface of said fabric member remains electrically-conductive."

Claim 1 also has been amended to recite that the flame retardant layer coating at least a portion of the interior surface of said fabric member, said flame retardant layer comprises at least about 50% by dry weight of one or more flame retardant additives. Support for the amendment may be found at page 10, lines 7-15 of the instant specification as filed, and further in the Example at page 14, lines 23-24.

In this regard, the specification describes the 30-50% range is based on the total weight of the emulsion. With the emulsion having a total solids content of about 60%, such 30-50% range therefore corresponds to a dry weight basis in the dried or otherwise cured film of the layer [*See* Specification, at page 14, lines 4-8], of between about 50-83%. For example, at 60% total solids, 100 parts by total weight of the emulsion contains 30-50 parts of the one or more flame retardant additives, and 60 parts by weight solids. On a solid or dry basis, *i.e.*, with the 40 parts water having been removed, the total weight of the layer is now 60 parts with between about 30-50 parts thereof, *i.e.*, about 50-83%, being the additive composition or concentration.

Claim 3 has been amended to correct an informality.

As the present claim program is believed to properly distinguish over the art of record, an early notice of allowance respectfully is solicited.

Respectfully submitted,

John A. Molnar, Jr.
Reg. No. 36,611
PARKER-HANNIFIN CORPORATION
6035 Parkland Boulevard
Cleveland, OH 44124-4141
Voice: (216) 896-2212
Fax: (216) 896-4027
E-mail: jmolnar@parker.com

CERTIFICATE OF MAILING

I hereby certify that this correspondence is being deposited on March 10, 2004, with the United Postal Service as first class mail in an envelope addressed to: Mail Stop Non-Fee Amendment, Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.

John A. Molnar, Jr.

CERTIFICATE OF SERVICE

I hereby certify that on July 1, 2008, I caused to be electronically filed a true and correct copy of the foregoing document with the Clerk of the Court using CM/ECF, which will send notification that such filing is available for viewing and downloading to counsel of record on the Court's CM/ECF registrants for this case. I further certify that on July 1, 2008, I caused a copy of the foregoing document to be served upon the following in the manner indicated:

BY E-MAIL AND HAND DELIVERY
William J. Marsden, Jr.
FISH & RICHARDSON P.C.
919 N. Market Street, Suite 1100
P.O. Box 1114
Wilmington, DE 19899-1114
marsden@fr.com

BY E-MAIL
John P. Pegram
Michael T. Zoppo
FISH & RICHARDSON P.C.
Citigroup Center
153 East 53rd Street, 52nd Floor
New York, NY 10022-4611
pegram@fr.com
zoppo@fr.com

/s/ Francis DiGiovanni
Francis DiGiovanni (#3189)